A RISK AND RELIABILITY MANAGEMENT
APPRAISAL OF COMPANY FAILURE

An application of risk and reliability management methodology to the analysis and identification of pattern, causes and symptoms of company failure, including formation of a Data Bank for failed companies.

by

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DEDICATION

TO MY PARENTS

A RISK AND RELIABILITY MANAGEMENT APPRAISAL OF COMPANY FAILURE

An application of risk and reliability management methodology to the analysis and identification of pattern, causes and symptoms of company failure, including formation of a Data Bank for failed companies.

The principal objective of the research is to diagnose the causes and symptoms of company failure and to investigate whether a pattern of failure could be determined to enable management and other interested parties to identify the risks threatening the survival of the company. The current research divides into three main areas

1. Development of a Data Bank and a study of the age structure of failed companies.
2. An application of reliability management techniques to the analysis of company failure data.
3. Identification of causes and symptoms of company failure based on risk management methodology.

Data were collected and analysed for approximately 2000 manufacturing companies which had undergone either compulsory or creditors' voluntary liquidation during the period 1970 to 1977. A Data Bank was established with classified information for 16 different groups of companies making up the manufacturing industry. The classification was based on the Standard Industrial Classification. A study of the age structure of each group was carried out and compared with previous studies.

Reliability methodology was applied to the analysis of company failure data for the identification of the failure pattern. Best distributions describing failure behaviour of companies were also determined and the validity and application of various statistical distributions were examined. A detailed examination of the histories of some large companies which failed during the period 1970-1977 was carried out. Risks, weaknesses and possible causes and symptoms of failure were investigated and discussed. A list of the causes of failure emerged from the analysis is drawn and the non-financial symptoms are highlighted in a tabular form. Illustrative models for the appraisal of change and identification of causes and symptoms are developed and critical factors discussed.

Finally, general conclusions arising out of the research are presented, along with recommendations for further research and study.

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INTRODUCTION

CHAPTER I

BUSINESS FAILURE

1.1 Introduction

The study of business failure is important both from the standpoint of internal management and from the standpoint of creditors with amounts owing from a company in distress. Some major company failures in recent years such as Rolls Royce, Court Line, Vehicle and General Insurance, Handley Page and Mitchell Construction have raised questions of improprieties in the management of these companies. The instabilities of the 1970s, with increased numbers of failures in all sectors of business has generated a renewed interest as to the occurrence and practical importance of company failure. In the past few years many large and well known companies with properly established systems and qualified executives of the highest calibre have encountered difficulties which have resulted in liquidation, take-over or massive and traumatic rescue operations and reconstruction. Inability of management to understand its organisation problems, resulted in development of crisis situations and final collapse.

The thesis of European psychologists is that "individual behaviour is determined primarily by previous events and experiences, not what lies ahead", which analogous to the companies where the problems and crisis of firms are rooted mostly in the past decisions and events rather than in present circumstances. Most of the management studies are often directed towards how things should be done, but there is also much to be learnt from a study of failed companies which shows how things should not be done and what happens when they go wrong.

Today, society is an environment which is changing more rapidly than ever before in history. These rapid changes of environment possess particular problems for companies, businesses and other similar institutions. To cope with these changes it is necessary for a company to objectively look at the direction in which it is actually going and compare with the direction it should be going. This is what the failed companies did not recognise in time. The threat of failure confronts many small, and particularly young, companies. As most businessmen come to realise the environment in which new firms are born is unfriendly and unconducive to to business survival, the result is a high mortality rate.

This study pays attention to failure pattern of companies, the increasing rate of business failure and deals with the period in the life of a company between the points where it is ailing and potentially failing and where its difficulties have not been diagnosed and it has finally collapsed.

1.2 Objectives

The aims of the present study are:

1. To develop a Data Bank consisting of approximately 2000 companies which went into liquidation, either voluntarily by creditors' or compulsorily by courts. This can provide information with regard to age distribution of companies for further analysis in the present study and more information for other studies in the field of business failure.

2. To analyse company failure data by application of the reliability management techniques to identify the time to failure distribution of data and pattern of failure in companies.

3. To examine the histories of failed companies in order to identify the causes and symptoms of failure and to find a common thread of failure which can outline a set of guidelines that will keep management abreast of the risks and avoid the misconception, errors and omissions committed by some failed companies.

1.3 Methodology

The methodology of the research is based on risk and reliability management which permits a step by step process of definition, data collection, analysis, interpretation, identification, description and finally allows conclusions to be formulated and presented regarding the manufacturing companies which failed during the period 1970-1977 in England and Wales.

Application of the methodology has resulted in a comprehensive classified Data Bank of failed companies with tabulated data which is subjected to statistical analysis later in the present study.

In addition to quantitative data, case studies and histories of large company failures are given and discussed in qualitative terms.

This methodology has proved useful in that it enables a precise and logical research to be established and followed. The first stage in the research was to arrive at an acceptable definition of failure. This was critical for following other stages, because it was essential to know what an event is before it can be analysed and predicted.

1.4 Definition

Many definitions of 'failure' are encountered in the general literature. Failure as defined in the Oxford Advanced Learner's Dictionary is "lack of success - state of not being adequate; non-performance of what is normal, expected or required." The definition of failure in management studies is vague, partly because there are varying degrees of failure. It has been defined in several ways according to the particular applications being studied. This term is often used loosely in the literature of business and economics. Dewing[54] distinguishes between economic and legal failure and writes "Broadly speaking, a business is an economic failure when the net return on the capital invested, after an allowance has been made for risk involved, is distinctly less than the prevailing interest rate on capital. A business is a legal failure when there is not available sufficient money to meet the legally forcible demands of creditors. In one case we are measuring business success and failure in terms of the earnings on invested capital; in the other case we are measuring the corporation's success and failure in terms of the ability of the corporation to meet its just liabilities."

Altman(4) defines failure by economic criteria as "the situation where the realised rate of return on invested capital, with allowance for risk, is significantly and continually lower than prevailing rates on similar investments." He also comments that "somewhat different economic criteria have also been cited, including insufficient revenues to cover costs and situations where the average return on investment is below the firm's cost of capital." Altman suggested when the company can no longer meet the enforceable demands of its creditors, it is called a legal failure.

Weston and Brigham(158) differentiate between economic and financial failure, i.e. "Economic failure usually signifies that a firm's revenues do not cover costs or a firm has failed if the rate of earnings on the historical cost of investment is less than the firm's cost of capital." They also describe the financial failure as: Technical Insolvency, when a firm cannot meet its current obligations as they fall due, even though its total assets may exceed its total liabilities, and Bankruptcy when the firm's total liabilities exceed a fair valuation of its total assets. The 'real' net worth of the firm is negative. Dunn and Bradstreet(58) - a leading supplier of relevant statistics on unsuccessful enterprises defines business failure as "those businesses that ceased operations following assignment or bankruptcy; ceased with loss to creditors after such actions as execution, foreclosure, or attachment; voluntarily withdrew leaving unpaid

EXHIBIT 1.1


TYPES OF COMPANY FAILURE
ECONOMIC
BUSINESS
FINANCIAL
LEGAL
Operating revenue < operating costs
Return on Investment < Firm's Cost of Capital
Firm's Actual Return < Expected Return
Unable to make profit
Reliance on new capital and loans
PARTIAL 'Technical Insolvency'
ABSOLUTE 'Liquidation'
Unable to meet current obligations
Assets may exceed liabilities
(Overtrading)
Real net worth of firm is negative
Receivership
Re-organisation
Liquidation
Negative ne
worth

obligations, were involved in court actions such as receivership, re-organisation, or arrangement; or voluntarily compromised with creditors".

Argenti[11] describes the most common words which are generally used in the study of business failure such as: insolvent, liquidation, receivership and bankruptcy. He writes "In Britain, companies do not go bankrupt (that is a term reserved for people only), they become 'insolvent' which means they cannot pay their debts as they fall due or that their net assets are of negative value. In this case the bank usually calls in a 'receiver' who takes over the management of the company and then does one of two things. He either continues trading with the permission of the creditors and others, in the hope of bringing the company or part of it round to profitability again, or he puts it into 'liquidation' which means the company stops trading and all its assets are sold for the benefit of the creditors."

The definitions adopted in the literature can be broadly classified as follows:

1. Economic Failure: This will be deemed to occur if one or more of the following conditions apply:

   a. the rate of earnings on the historical cost of investment is less than the firm's cost of capital

   b. Annual returns have fallen below expected returns

   c. Revenue does not cover costs.

   d. The net return on the capital invested, after allowance for risk, is distinctly less than the prevailing interest rate on capital.

2. Financial Failure: Two common terms used with respect to financial failure are:

   a. Technical Insolvency. This refers to a state in which a firm finds itself unable to meet its current obligations even though its total assets exceed its total liabilities. This signifies lack of liquidity. Technical insolvency may be a temporary condition and is easily detectable.

b. Bankruptcy. A firm has failed in this sense when its total liabilities exceed a fair valuation of its total assets. This is a more critical condition; and indicates a chronic rather than a temporary illness. The real net worth of the firm is negative.

3. Business Failure: This type of failure is the most common one which represents the inability of a firm to make a profit.

4. Legal Failure: When the company can no longer meet the legally enforceable demands of its creditors. This type of failure usually precedds such a comprehensive recapitalisation that the whole procedure may be called re-organisation. Legal failure ends up either through liquidation or re-organisation. The companies which go into receivership can be named as this type of failure when the receiver attempts to sell their assets as a going concern. This does not mean that the business itself will be destroyed.

There are different types of liquidation, of which the following are the principal ones:

1. Compulsory liquidation (winding up by court)
2. Voluntary liquidation
    2.1 Creditors' voluntary liquidation
    2.2 Members' voluntary liquidation
3. Liquidation or winding up subject to supervision of court.

These are described in detail in Chapter 3.

The definition of failure adopted for the present study is that of insolvency when the company has appointed a liquidator either by creditors' voluntary liquidation or by court and compulsory liquidation. Exhibit 1.1 shows various types of failure.

1.5 Scope of Business Failure

Chart 1.2 gives a clear conceptual picture of the scope of business and company failure studies. These include:

1.5.1 Identification of causes and symptoms

An essential part of any study is to define and identify the problems, the underlying causes of trouble and the signs of weaknesses in advance of failure. The importance of this stage of analysis is illustrated by the adage "A problem identified is half-solved, and a danger foreseen is half-avoided". The analysis can be divided into financial and non-financial.

1.5.2 Prediction of failure

Application of statistical techniques, such as multivariate discriminate analysis and probabilistic models in the analysis of financial behaviour of companies has provided valuable prediction models. The models have been developed by different authors in attempts to identify the companies at risk up to four or five years prior to bankruptcy. The accuracy of these models, which are often called Z models, diminishes substantially as the lead time increases, e.g. Altman[4] model has proved 95% successful in prediction of failure one year before the company actually fails, 72% for the second year and only 36% with five years of the forecast. Taffler[144] claimed 98% accuracy in identifying the companies at risk for the first year before failure. Townsend[149] claims 92% accuracy in the first year for his model whilst Hawkins[84] demonstrated an 87% accuracy for an initial sample and 82% for his secondary sample in the year before failure. The range of accuracy differs in some degree with each model. These appear reasonably accurate for short-term forecasting.

Other prediction models have been developed based on financial information of companies and causal analysis which can be used in conjunction with Z models to provide a more effective prediction tool. The main purpose

EXHIBIT 1.2 Scope of Business Failure

of prediction models is to identify the companies which are prone to failure in advance. These can be used by management, bankers, creditors, investment analysts, stock brokers and other interested groups.

One striking point relating to the prediction models is that they do not predict the time to failure of a company, but classify companies at risk on the basis of resemblance of their financial characteristics with those of previously failed ones. This means they are not predictive in a conventional sense. One can also predict the probability of failure or survival of companies at different stages in their life cycle and identify the pattern of high risk phases. This appraisal is explained in Chapter 4 of the present study.

Finally, it is of interest to recall Altman "A prediction model will not under normal circumstances be the physician and panacea to the sick patient. It merely serves as objective quantification of the patient's illness, but it cannot point directly towards the areas of most pressing need".

1.5.3 Prevention of failure

Having identified the causes and symptoms of failure and assessed the propensity of a company to fail the next step from the point of view of management is to prevent the failure. This is often confronted by two important questions which are the 'Will' and the 'Ability'. The first questions should always be asked since the concept of capitalism includes Darwin's rule of 'survival of the fittest'. In a capitalist system the resources of society are transferred from one application to another deemed to be more useful by the decline and failure of companies that are not using resources usefully and by the rise and success of companies that are. The question is whether one damages the efficiency of capitalism if he or she attempts to reduce the number of failures. Argenti[11] suggests that "one has not to prevent all failures blindly, nor mindlessly to increase them, but to 'regulate' failure in order to improve the efficiency of capitalism as a means of allocating the resources of society but with due attention to possible consequential hardship and harm to vulnerable members of society." Voluntary re-organisation and corrective actions and control on time can prevent the company to go into the hands of the receivers and liquidators. Although 're-organisation' in its legal form is used when the company is insolvent, the author believes that re-organisation in this part means a radical change and severe actions to avoid disaster and correct the defects in systems. This needs a proper monitoring and control in all departments with standard criteria for measurement and responsible body to do the job adequately. Preventive actions vary in different companies according to their size, type and severity of problems. An important point in the prevention of failure is that it must be planned, the main objectives and their alternatives should be clearly identified and not consist of a series of impromptu reactions to the emergencies as they arise. Allsopp[3] quotes "External assistance from bankers or additional investment by proprietors, either in the form of temporary loans or permanent capitals is much more likely to be forthcoming where they see management has grasped the situation and knows how it is going to regain viability." He also suggests a plan including identification and assessment of the following:

a. the cause and history of difficulty

b. the present situation

c. the proposed remedy and objectives to be attained and the foreseen programme of events

d. the capital, revenue and expenditure budgets for the period of recovery.

e. the effect of repayment or servicing of any additional capital needed.

The author believes the difference between prevention and re-organisation is that in the former there is nothing fundamentally wrong with the company and some tactical re-arrangements are appropriate e.g. the implementation of tighter planning and control system, the introduction of improved or supplementary products, while in the latter case the company needs both strategic and tactical responses, for example in the area of strategic responses one should consider:

a. a major change in activity

b. the sale of company operations

c. liquidation at an early date

and for tactical responses:

a. changing the image or name

b. sale of a minor activity or acquisition of minor or additional activities by purchase or take-over.

1.5.4 Rescue operations

Having recognised some or all of the warning symptoms and realising the existence of the problems, it is necessary to consider alternatives available: rescue, receivership or liquidation. In the general sense, re-organisation, turn-around and receivership are considered as an extreme and ultimate group of remedies. For any rescue operation to succeed, it is essential that a capable management is introduced to the firm. In the financial sense, re-organisation is a process involving a recasting of the capital structure which the corporation is compelled to undergo either because insolvency has been evidenced by a default on an obligation or because such a default is imminent. The process is ordinarily carried out during receivership or bankruptcy. It may result in the formation of a new corporation.

Guthmann and Dougall[72] outline the purposes of re-organisation as:

a. to find and, if possible, to eliminate the operating and managerial causes of the difficulty

b. to reduce fixed charges

c. to reduce or eliminate floating debt

d. to simplify the capital structure and facilitate future financing

e. to raise new funds for working capital or property rehabilitation.

The first question to be answered is whether the company is better off 'dead or alive' - whether it should be liquidated and sold off piecemeal or be rehabilitated. "When a business becomes insolvent, a decision must be made whether to dissolve the firm through liquidation or to keep it alive through re-organisation. This decision depends upon a determination of the value of the firm if it is to be rehabilitated versus the value of the sum of the parts if it is dismembered."

Rescue operations vary greatly with the circumstances of the individual companies which may require a mild or drastic treatment. If a voluntary rescue operation and turn-around is not possible or is not desirable, then the next alternative to be considered is receivership. Receivers, in general, either continue trading with the permission of the creditors and others, in the hope of bringing the company, or parts of it, round to profitability through drastic changes and re-organisation, or he puts the company into liquidation which means the company stops trading and all its assets are sold for the benefit of the creditors. Adkins(1) suggests that in a rescue operation one has to find the right answers for the following items:

a. is it really the best choice ?

b. is it possible to achieve ?

c. Will it simply put off the evil day ?

d. What part does pride play ?

e. what is the quality of management, employees, equipment and products ?

f. the continuity of the company

1.5.4.1 Liquidation

The term 'liquidation' is applied when the business is wound up and the assets are converted into cash which is distributed to the owners and creditors. This is usually the result of a condition in which no treatment, mild or drastic, can remedy. Although "solvent corporations are liquidated merely because profits are unsatisfactory, the majority of companies which reach the liquidation stage are discontinued because of inability to meet maturing debts."(4) If there is no debenture and therefore no means of appointing a receiver, and it has been decided that the company cannot continue then the only alternative is liquidation. If the directors will not act, it is likely that a creditor or creditors will themselves take action and will petition the court for the compulsory liquidation of the company. This should not be necessary and, if the directors recognise the position, they themselves should take the necessary steps to place the company into creditors' voluntary liquidation. The details of various types of liquidation are given in Chapter 3 of this study.

The essential factor in a rescue operation is 'timing'. A company must not be put into liquidation if it is possible to avoid failure, but at the same time, to delay this most difficult decision is, as some experts believe, tantamount to fraud. Fraud is used here in the broad sense of the word and it refers to management's having the necessary knowledge of its precarious situation but refusing to admit failure.

Another important point is that financial re-adjustments could not by themselves, rehabilitate the company. This is often overlooked in rescue and re-organisation of ailing companies. A large number of previously re-organised companies which have failed after a short period give evidence of the ignorance of the conditions and requirements for this process.

1.5.5 Impact and consequences of company failure

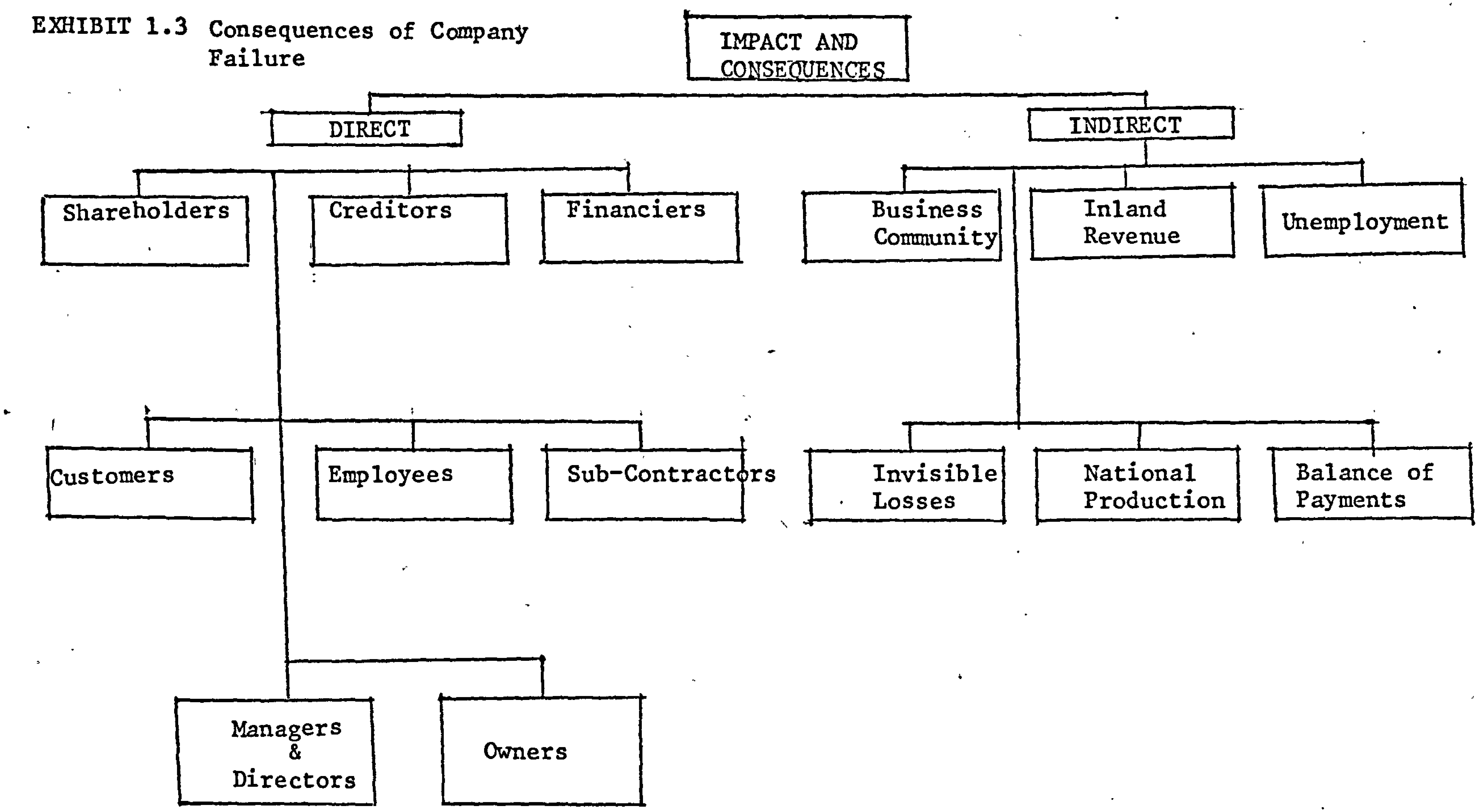
It is a common belief that every company like every product has a life cycle - it is born, it grows and some day it dies or even gets killed - some are short and brutal but most are long and lingering. However, as Cork[46] points out "we have learnt that a capitalist business must not be a ruthless business; that the art of earning money is to earn it for a service to the community and not for holding the community to ransom."

Failure of a company is as an asset lost to the community, an asset that has cost a lot of money and a lot of skill to build up. The loss of a business and the failure of a company is a misfortune to its owners, creditors, employees, and even customers. "Investors place their funds in a business with the expectation that the value of the funds will not only be preserved but enhanced."[46] A business failure destroys these expectations. The extent of failure consequences vary depending upon the various factors such as size and type of company, type of failure and type of industry. Broom et al[30] believe that "business mortality is a personal tragedy to the entrepreneurs who fail and, at the same time, a source of social waste." They also state "there are a number of reasons why business failure constitutes a tragedy." Among these are the following:

1. Loss of capital on the part of the entrepreneur and creditors.
2. Psychological effect on the individual
3. Elimination of a source of goods and services
4. Reduction of employment
5. Decreased tax payments

Argenti[11] expresses his view as "Corporate collapse has always brought fearful mental pain to proprietor, entrepreneurs, managers and their families. It has always meant that employees lose their jobs, shareholders lose their savings, creditors lose cash and future business, the customer

EXHIBIT 1.3 Consequences of Company Failure



is deprived of the product. It ruins lives and pushes its victims to the edge of suicide and beyond." Allsopp(3) describes the impact of failure and its consequences to the manager and executive, employee, suppliers, customers and community and concludes "In an ideal world a business that is no longer viable would be run down and eventually cease trading with the minimum of consequential loss to the subscribers, creditors, and employees."

Having considered the views of a few authors on the impact of company failure, the author concluded that one can possibly divide the consequences of failure into two categories as follows:

1.5.5.1 Direct impacts

This means the result of failure on all interested parties to the company in a direct, fast and early apparent term. As can be observed from the chart, the parties involved in this category are those quite close to the company's day to day running in one way or another and are affected by the failure of company almost immediately: they are in danger of losing their job, savings, holdings, reputation, investment, customers, market demand, product, service and even business. The impact and the degree of consequences vary depending upon their ability to manage the risks and crisis and also their dependency on the failed company.

1.5.5.2 Indirect impacts

This category is referred to circumstances when the consequences of a company failure are slow, late and not specifically apparent in the short term. The examples are the impact of business failure on national production, loss of exports, number of new businesses, tax payments and unemployment figures. The main difference, the author believes, is that in the former category the consequences and impact can be individually identified and even measured while in the latter case this is often impossible. Finally, whatever the category one might accept, the country loses, when the rate of failure rises, through its balance of payments.

Exhibit 1.3 gives a clear picture of direct and indirect impact and consequences of company failure.

1.6 Plan of Thesis

Chapter 2 of the thesis contains a review of the existing literature and relevant works on business and company failure. It includes the financial and non-financial studies which have been presented in the following order:

a. Financial studies

This part of the chapter describes the prediction models, based on univariate and multivariate analysis of financial ratios, which have been developed by different authors in order to spot the companies at risk in advance and predict the bankruptcy before it actually occurs. The strength and weakness of these models have been assessed in the end of this section.

b. Non-financial studies

The second part of Chapter 2 presents the views of experts, summary of works and conclusions drawn from the previous researches with regard to analysis of causes and symptoms of failure in small and large companies, business mortality, patterns and cycles of company failure, turnaround and rescue operations. A general assessment of these works is given at the end of this chapter.

Chapter 3 describes the process of development of a Data Bank consisting of approximately 2000 manufacturing companies which went into liquidation either voluntarily (by creditors) ot compulsorily (by court) during the period 1970-1977. An analysis of birth and death statistics of companies in the UK in the above period and the methodology of this study are also given in detail. The final part of this chapter is devoted to the interpretation of the tables drawn from the computerised list of Data Bank regarding the age structure of failed companies according to their group of industry and year of failure. The results and conclusions have been compared with the previous studies in this area.

Chapter 4 is devoted to the application of reliability management methodology to the analysis of company failure data and identification of the pattern of failure. A brief review of reliability concepts and statistical distributions is made. The distributions used for the analysis of data are:

Log-normal

Weibull

Gamma

Exponential

Mixed-Weibull

The chapter describes the analysis of failure data, the application and validity of distributions and presents the best distribution which can describe different failure patterns. The plots of the empirical data fitted into the above distributions are also given.

Chapter 5 of the present study has been devoted to the application of risk management methodology to the identification of causes and symptoms of company failure data. It provides a review of the functions and scope of risk management and compares its concept with company failure studies. The companies selected for this analysis are some of the major companies which have failed in recent years and have been investigated by the inspectors appointed by the Department of Trade, or the experts. This chapter discusses the development and evolution of firms, the problems and difficulties of small businesses and examines the individual cases to identify their causes and symptoms of failure. A list of causes of failure which is derived from the companies studied and a categorical table and chart of non-financial symptoms of failure are also given. The final part of this chapter is the description of processes of failure, discussion of the most critical factors, development of an illustrative model for change appraisal and the conclusions drawn from this study.

Chapter 6 brings together the main conclusions drawn from the previous chapters and presents recommendations for further researches in this field.

It should be noted that the data analysed in this research refers to a period (1970 to 1977) when the British economy was highly unstable. Care, therefore, needs to be exercised when interpreting results. As it must not necessarily be assumed that investigation over a different period or in a different economy will produce the same findings. However, the author is of the opinion that notwithstanding the differences in time or conditions (e.g. other countries), one can still apply the methodology developed in the present study to identify those companies in actual or potential trouble.

A REVIEW OF BUSINESS FAILURE LITERATURE

CHAPTER 2

A REVIEW OF BUSINESS FAILURE STUDIES

2.1 Introduction

The main objective ~~of this chapter~~ is to approach the subject of business failure via a survey of existing literature and the tentative conclusions based on what has been found about the concept and scope of company failure and business mortality.

This review was deemed essential to exploit research findings and to spotlight weaknesses. This proved an invaluable aid to designing the present research. Although a certain amount of British studies have appeared in this field of management, their volume is small in comparison with those inspired by the US. In order to judge the individual usefulness and type of study the author classified all these works into the following categories:

1. Financial Analysis
   - 1.1 Univariate analysis
   - 1.2 Multivariate analysis
2. Non-Financial Analysis
   - 2.1 Causes and symptoms of failure
   - 2.2 Other areas of company failure

2.2 Financial Analysis

2.2.1 Univariate Studies

Univariate analysis is an approach of prediction of company failure which uses financial ratios taken one at a time in order to predict whether or not a given company is a member of some predetermined class of companies. This approach was used by many researchers in America as early as 1931, Fitzpatrick (1931,1932)[64], Winakor and Smith (1935)[134] and Merwin (1942)[112], to indicate that failing firms have different ratio patterns to continuing firms.

One of the most useful essays on the subject of univariate studies in relation to impending failure is that of Dev (Dev, S., 1974)[53] which provided a summary of ratios and best discriminators of previous researchers.

Tamari (1964)[146] compared ten ratios calculated from the accounts of 28 industrial firms with those of all Israeli industry between 1950 and 1960 and found that the financial ratios may be predictors of failure up to 5 years before bankruptcy. He also found that the failed company ratios were significantly worse than the all-industry ratios in the year prior to failure and most had been deteriorating for up to five years prior. This study gave support to the current ratio and the ratio of net worth to total debt as a means of forecasting bankruptcy by including them with four other ratios to compose an index as a signal for solvency and risk. He concluded that "... the analyst cannot rely on one ratio alone in measuring the degree of risk", and therefore attempted to develop a linear discriminant function for better risk measurement..

Although the Tamari study was the only major univariate study in this field to have been undertaken outside the United States, it inspired other researchers in the USA and UK to investigate the predictive power of financial ratios using statistical techniques and empirical data.

TABLE 2.1 Ratios shown to be Good Discriminators between Failed and Non-Failed Companies in Univariate Studies

Author and Year of Publication	Fitzpatrick 1931	1932	Smith 1930	Smith & Winakor 1935	Ramser & Foster 1931	Merwin 1942	Tamari 1964	Beaver 1966 & 1968
Current Asset and Liability Ratios								
Current					x	x		
Quick or 'Acid Test'	4th				x		x	
Stock/Current Assets					x			
Capital Structure Ratios								
Net Worth/Total Liabilities	3rd	x				x	x	
Net Worth/Total Assets (a)					x			
Total Liabilities/Total Assets								3rd
Net Worth/Fixed Assets	2nd	x	x	x	x			
Reserves/Total Assets			x					
Asset Structure Ratios								
Fixed Assets/Total Assets			x	x				
Current Assets/Fixed Assets (a)					x			
Working Capital/Total Assets			x	Best	x	Best		
Net Profit Ratios								
Net Profit/Net Worth	Best	x			x			
Net Profit/Total Assets					x			2nd
Net Profit/Sales					x			
Sales Ratios								
Sales/Stock					x			
Sales/Total Assets					x			
Sales/Net Worth					x			

TABLE 2.1 (Contd.)

Author and Year of Publication	Fitzpatrick 1931	Fitzpatrick 1932	Smith 1930	Smith & Winakor 1935	Ramser & Foster 1931	Merwin 1942	Tamari 1964	Beaver 1966 & 1968
Cash Flow Ratios								
Cash Flow/Total Debt								Best
Other Data								
Number of Ratios Tested	13	13	24	21	33	Many	10	30
Number of Failed Companies	20	20	29	183	51(b)	200	28	29
Year in which Failures Occurred	1920-29	1920-29	1923-28	1923-31	1920-27	1926-36	1958-60	1954-64
Country Studied	USA	USA	USA	USA	USA	USA	Israel	USA

(a) To facilitate comparison with the original studies, equivalent ratios have been bracketed together rather than give a single description

(b) This is an approximation as the exact information was not given in the study.

Source: Dev. S. In Debits, Credits, Finance and Profits, 1974.

It is the author's opinion that the ratios in the above table can be of value to future researches in financial analysis of companies.

MERWIN (Merwin, C L, 1942)(112)

One of the early works on the predictive power of financial ratios carried out by Merwin (1942) who tested a set of selected ratios for a sample of 939 small firms in five manufacturing industries in the USA over a period of 11 years. He concluded that three of the ratios provéd to be indicators of the discontinuance of a firm in business. These ratios were the current ratio, net worth of total debt, and net working capital to total assets.

The predictive power of these ratios may reveal signs of weakness in discontinuing firms as clearly as 4 or 5 years before the date of discontinuance.

Merwin classified a firm as 'failed' when it failed to have filed a tax return for six consecutive years and then to have failed to file a return in one of the subsequent years. There are a few critics who comment that not all firms which stop filling tax returns are in financial difficulties, reasons could be liquidation of a profitable business, merger of one firm to another or change in name. He compared various aggregate mean ratios of the failed firms with the aggregate mean ratios of non-failed firms.

BEAVER (Beaver, W H, 1966)(17)

Beaver's study was based on the analysis of 30 ratios that are popular in the financial literature to test the predictive power of these ratios as predictors of company failure in the USA. The ratios were classified into six groups and the best performing ratios in terms of overall predictive accuracy in each group ranked, as among themselves, in the order shown in Table 2.2.

Cash flow to total debit was the best ratio with 87% accuracy in predicting failure for 79 failed firms and non-failure for 79 non-failed firms at the first year before failure (the failed and non-failed firms were

TABLE 2.2

Ratios	Prediction*(1)
Cash flow to total debt *(2)	Non-failed > failed
Net income to total assets	Non-failed > failed
Total debt to total assets	Failed > Non-failed
Working capital to total assets	Non-failed > failed
Current ratio	Non-failed > failed
No-credit interval	Non-failed > failed

*(1) Non-failed > failed is a prediction that the mean value of the non-failed firms will be greater that that of the failed firms

*(2) Debt is defined as current plus long term liabilities plus preferred stock.

Source: Beaver, Journal of Accounting Research, Vol. 4

similar in terms of size as measured by total assets value). The predictive accuracy of this ratio was also high for the second through fifth years before failure ranging from 75% to 80%. The Beaver study is the major srudy of a univariate nature and is regarded as a classic in the study of predictiveness of financial ratios. He views the firm as a reservoir of liquid assets which is supplied by inflows and drained by outflows. The solvency of the firm is defined in terms of the probability that the reservoir will be emptied.

Beaver suggests that there are four important concepts in drawing the relationships between the liquid assets flow model and the ratios, namely:

1. The size of the reservoir
2. Debt of the firm
3. Net liquid flow from operations
4. Fund expenditure for operations

Given these concepts, he states:

"a. The larger the reservoir, the smaller the probability of failure..

b. The larger the net-liquid asset flow from operations (i.e. cash flow), the smaller the probability of failure.

c. The larger the amount of debt held, the greater the probability of failure.

d. The larger the fund expenditure for operations the greater the probability of failure."

FITZPATRICK (Fitzpatrick, P J, 1931 and 1932)(64)(65)

The Fitzpatrick studies of 1931 and 1932 were among the earliest works in this field which compared the certain selected ratios between 19 failed and 19 non-failed firms during the period 1920-1929. He employed a paired sample in terms of asset size, financial statement date and industrial classification. The second study constituted the comparison of 13 ratios for each of 19 failed companies with those of 19 successful companies. Analysis of the trends of 13 ratios for 3-5 years prior to the failure showed that although all ratios predicted failure through declining trends, the best predictors among the above ratios were:

Net profit/Net worth

Net worth/Total debt

The main criticisms of these studies include the limited sample size and lack of a clear definition of failure.

SMITH AND WINAKOR (Smith, R F & Winakor, A H, 1935)[135]

This study was an extensuon of an earlier work by Smith and examined the changes and trends of the mean value of 21 ratios for a sample of 183 firms which had failed by 1931 over a period of 4 to 10 years prior to failure. They defined failure if a firm:

1. Entered into receivership
2. Defaulted on its bonds
3. Underwent a financial readjustment which resulted in material changes in the right or equities of the owners and creditors.

The mean asset size of the sample, which was mainly chosen from Moody's Industrial Manual was $12,200,000.

They concluded that the overall results were similar to those of Smith's earlier research. There were certain ratios ".... whose trends resulted in an uninterrupted indication or symptoms of weakness for the majority of companies in at least the last 8 years before failure.(Smith, R F, 1930). They concluded that the ratio of working capital/total assets was the best indicator of future failure where decline began 10 years before the occurrance of financial difficulties. The main weakness of this study is the lack of a matched sample of continuing firms or a control sample.

2.2.2 Multivariate Discriminant Analysis

This is a statistical technique used to classify an observation into one of several groupings dependent upon the observation's characteristics. The first step is to establish explicit group classification. The number of original groups can be two or more. It is used primarily to classify and/or make predictions in problems where the dependent variable appears in qualitative form, e.g. male or female, bankrupt or non-bankrupt. This technique has the advantage of considering an entire profile of characteristics common to the relevant firms, as well as the interaction of these properties. A univariate study, on the other hand, can only consider the measurement used for group assignment one at a time. This technique, using financial ratios, has been employed by many authors in the field of management and finance in dealing with the forecasting of failure for manufacturing companies (Tamari, 1966; Altman, 1968; Blum, 1974; Taffler, 1977; Townsend, 1978 and Hawkins, 1978), for companies in general (Deakin, 1972), small firms (Edminster, 1972), for banks (Meyer and Pifer, 1971), for railroads (Altman, 1973), for insurance companies (Freischmann and Pinches, 1973, 1974).

ALTMAN (Altman, E L, 1968)[4]

This is the first study undertaken to investigate the discriminatory power of financial ratios utilising multiple discriminant analysis. The initial sample was composed of 66 corporations with 33 firms in each of the two groups. The bankrupt group were manufacturers that filed a bankruptcy petition during the period 1946-65. The mean asset size of these firms was $6.4 million with a range of between $0.7 million to $25.9 million. Group 2, which were still in existence in 1966, consisted of a paired sample of manufacturing firms chosen on a stratified random basis by industry and by size. The next stage was to compile a list of 22 potentially helpful variables (ratios) for evaluation. These ratios were classified into 5 standard ratio categories as:

a. Liquidity ratios

b. Profitability ratios

c. Leverage ratios

d. Solvency ratios

e. Activity ratios.

The selection of ratios was based on

1. Popularity in the literature

2. Potential relevancy to the study

3. A few new ratios initiated in this study

From the original 22 ratios, 5 ratios or variables were selected as best global indicators in the prediction of corporate bankruptcy. The final discriminant function was as follows:

$$Z = .012X_1 + .014X_2 + .033X_3 + .066X_4 + .999X_5$$

where

X_1 = Working capital/Total assets

X_2 = Retained earnings/Total assets

X_3 = Earnings before interest and tax/Total assets

X_4 = Market value equity/Book value of total debt

X_5 = Sales/Total assets.

Z = Overall Index.

Altman, in this study which has been described in detail in his book 'Corporate Bankruptcy in America', calculated that there is an area of uncertainty between 1.81 and 2.99 which is defined as a grey area or zone of ignorance because of the susceptibility to error classification. He concludes that all firms having a Z score of greater than 2.99 clearly fall into the non-bankrupt sector, while those firms having a Z below 1.81 are all bankrupt.

The predictive accuracy of this model was 95% one year prior to bankruptcy, 72% for 2 years, 48% for three years, 29% for four years and 36% for five years prior to bankruptcy. It is realised that the accuracy of the model falls off consistently with the one exception of the fourth and fifth years. The most logical reason, Altman comments, for this occurrence is that after the second year, the discriminant model becomes unreliable in its predictive ability. One would expect that as the lead time increases, the relative predictive ability of any model would decrease. This was true in univariate studies cited earlier, and it is also quite true for multivariate discriminant analysis and models.

Based on results, Altman suggests, that "the bankruptcy prediction model is an accurate forecaster of failure up to two years prior to bankruptcy and that the accuracy diminishes substantially as the lead time increases."

TAFFLER (Taffler, R, 1977)[144]

The Taffler study is the first comprehensive work in the development of Z models specially to analyse UK manufacturing concerns. He has employed multivariate discriminant analysis technique for the identification of potentially bankrupt manufacturing companies in advance of failure.

Taffler believes that his final statistical model using a stepwise discriminant approach and financial ratio data is able to identify subsequently failing companies with 98% success rate.

This study consisted of failure as insolvency and those situations in which companies were unable to continue in business through inability to meet outstanding financial obligations as a result of factors under the control of the company and where loss to creditors and shareholders consequently results or would have resulted without action by the government.

Taffler considered a sample of 46 failing and 46 non-failing companies, matched by size and industry. From 80 potentially discriminatory ratios, four were shown to be able to predict with 98% accuracy the classification of his initial sample one year prior to failure. The final function was derived in the form:

$$Z = C_o + C_1R_1 + C_2R_2 + C_3R_3 + C_4R_4$$

where

Z = overall index

R_1 = Profit before tax/Current liabilities

R_2 = Current assets/Total liabilities

R_3 = Current liabilities/Total assets

R_4 = No-credit interval: this calculates the time for which the company can finance its continuing operation from its immediate assets if all sources of short term finance are cut off

C_o = a constant

C_1-C_4 = ratio weights or coefficient.

Although the relative importance of each ratio was given, the actual coefficients and the constant corrective were not which makes further comment difficult.

Taffler calculates a cut-off point and suggests a danger and a solvent region. Any firm with a Z-score in the 'danger' region can be considered a potential failure and the more negative the rating and the more years for which it is below zero the more likely the firm is to go bankrupt. On the other hand any company with a score lying anywhere in the solvent region can be considered a virtually 100% safe bet.

It should be noted that the presence of a company in danger region only indicates, strictly speaking, that it financially resembles previous bankrupt firms, not that it will necessarily fail. However, it is a stimulus for further investigation of company performance.

EDMINSTER (Edminster, R ., 1971)(60)

Edminster took a sample from firms which had either received loans or loan guarantees from the Small Business Administration (BSA) in the USA, and used multiple discriminant analysis to discriminate between failed and non-failed businesses. He examined the ratios of 21 loss borrowers and a similar number of non-loss borrowers. The mean asset size of the firms was $116,700 for failed and $213,000 for the non-failed ones which indicates that the study was towards the small corporations. He concluded that his linear discriminant function, containing seven variables, predicted failure more successfully than did any single ratio. The final function obtained was of the form:

$$Z = 0.951 - 0.423X_1 - 0.293X_2 - 0.482X_3 + 0.277X_4 - 0.452X_5 - 0.352X_6 - 0.924X_7$$

$Z = 1$ for a successful (non-loss) business

The function was able to predict with 92% accuracy on the original sample.

This study suffers from a number of drawbacks which Townsend and Gru referred to as:

1. Small sample size
2. Lack of hold out sample
3. Biased population - apparently to receive a loan from the SBA, the borrower must have been refused credit by at least one bank, hence a higher likelihood of failure.
4. Exclusive use of zero-one dummy variables. Gru points out that by the use of such variables to describe continuous quantitative variables is an inefficient use of data.

Edminster is, however, vague as to how he defines business failure, his research design states: "Multiple discriminant analysis is employed to select a set of ratios which best discriminate between loss and non-loss borrowers and guarantee recipients". It would mean if the Small Business Administration had written off a loan as a loss the business was considered a failure otherwise a success.

GRU (Gru, L G, 1973)(71)

This is another study on small businesses and was designed to develop a model capable of predicting the failure of small businesses in the US. The purpose was to assess whether financial ratio analyses together with the use of multivariate discriminant analysis could be useful in this type of business, with a view to its usefulness to crddit analysts in assessing credit worthiness of potential debtors.

A small business was defined as one with total assets less than \$2,200,000. Failure was considered when a firm declared itself bankrupt (US usage). The sample consisted of 34 failed and 34 non-failed firms as a primary sample and a secondary sample of 15 non-failed and 13 failed firms. The model contained five variables or ratios which showed a good result for both primary and secondary samples. This model predicted the failure for small businesses with 94% accuracy for the primary sample, and 86% accuracy for the secondary sample. The best function obtained was:

$$Z = 0.07877X_1 + 0.02256X_2 + 0.01643X_3 + 0.07180X_4 - 0.04144X_5$$

where

X_1 = earnings before taxes plus depreciation/Total debt

X_2 = Working capital/Total assets

X_3 = Net sales/Total assets

X_4 = Operating profit/Total assets

X_5 = Total debt/Total assets

Z = Discriminant score

Z_2, X_3 and X_4 are the same ratios that Altman had previously used in prediction of large manufacturing companies.

One of the major drawbacks of this study is the period for collecting data which was only 16 months before the date of failure and is not a significant duration for prediction.

LIS (Lis, 1972)[102]

This study is the first one in the UK which was published in an article by Bolitho in the Investor's Chronicle (1973, March). Lis took a sample of 30 listed companies which had failed between 1964 and 1972, and 30 non-failed companies matched by size, year and industry. He claimed to be able to predict to within 90% of accuracy whether a company is financially insolvent. He based his claim on the use of four ratios which could be calculated from information contained in the latest published balance sheet of a company. These four ratios were:

X_1 = Working capital/Total assets

X_2 = Earnings before interest and tax/Total assets

X_3 = Total retained earnings/Total assets

X_4 = Total net worth/Total debts

where

Working capital = current assets - current liabilities

Total assets = current assets + fixdd assets - goodwill

Earnings before interest and tax = Trading profits minus such items as depreciation, auditors'remuneration, hire of plant and directors' emoluments.

Total retained earnings = retained profits after all scrip issues made from revenue reserves have been included

Total net worth = All funds directly attributable to ordinary shareholders.

Total debt = All short and long term borrowings plus redeemable preference shares

These ratios were drawn from an analysis of certain previous literature particularly Altman's 1968 study. The final function was

$$Z = 0.06289X_1 + 0.09241X_2 + 0.05739X_3 + 0.0143X_4$$

Z = Overall Index

The cut-off point was 0.027 and in general terms, the higher the value above this, the greater the certainty that a company is financially sound.

BLUM (Blum, M P, 1974)(24)

The focus of this study was to construct a theoretical model, based on accounting and market data, which can distinguish failing from non-failing firms. Data were collected for 115 failed and for 115 non-failed firms. The unfailed firms were paired with the failed firms by criteria of industry and size. Failure was predicted with an accuracy of 80% when it occurred two years into the future. It was predicted with an accuracy of 70% when it o-curs three, four and five years in the future. Failure in this study was based on the following criteria with three common denominators: profitability, liquidity and variability.

1. Inability to pay debts as they came due
2. Entrance into a bankruptcy proceeding
3. Explicit agreement with creditors to reduce debts.

The period of study was during 1954-58. The failing company model was constructed from the following ratios:

1. The 'quick-flow' ratio
2. Net quick assets/Inventory

3. Cash flow/Total liabilities
4. Net worth at fair market value/Total liabilities
5. Net worth at book value/Total liabilities
6. Rate of return on common stockholders who invest for a minimum of three years
7. Standard deviation of net income over a period
8. Trend breaks for net income
9. Slope for net income

10-12 Standard deviation, trend breaks and slope of the ratio, net quick assets to inventory:

Variable 10, 11 and 12 are only used at the first and second year before failure. The coefficients of ratios were calculated for various previous years data. Discrimination was not found to be statistically significant at the sixth year prior to failure.

This model exhibited better long term predictive accuracy, but its use is more difficult due to the information required. The principal hypothesis to be tested in this study was that the failing company model could discriminate failed from nonfailed firms by means of the quantitative profile provided by the twelve variables.

TOWNSEND (Townsend, T G, 1978)[149]

Townsend in an investigation into the use of models in predicting failure or acquisition, and their use to the business policy maker in determining the characteristics of impending failure, comprised a primary sample of 25 failed companies, 25 acquired companies and 25 non-failed companies. The companies being matched for industrial classification, approximate asset size and for the same accounting period. Financial data was collected for a period of three years prior to failure or acquisition. For each of the firms and for each year the following ratios were calculated:

X_1 - Working capital/Total assets

X_2 - Retained earnings/Total assets

X_3 - Earnings before interest and tax/Total assets

X_4 - Market value of equity/Book value of total debt

X_5 - Sales/Total assets

From these values two separate discriminant scores were calculated:

$$Z_1 = 0.012X_1 + 0.014X_2 + 0.003X_3 + 0.006X_4 + 0.0099X_5$$

$$Z_2 = 0.012X_1 + 0.014X_2 + 0.003X_3 + 0.006X_4$$

It was found for all the above measures, save in two instances, out of 42 companies made; that:

Performance of non-failed > performance of acquired > performance of failed

The models were developed based on the Altman model to predict acquisition or failure of UK companies, using the technique of multiple discriminant analysis. The model was not able to satisfactorily discriminate between acquired and non-failed companies and did not seek to attempt to discriminate between failed and acquired companies.

The best acquisition model could accurately predict 88% of the acquisition whilst the best failure model 92% of the failure.

Townsend also used a secondary sample of failed and acquired companies.

HAWKINS (Hawkins, J W 1978)(84)

Hawkins used the technique of multiple discriminant analysis in analysing 25 potentially discriminating ratios and developdd a model ultimately utilising 6 of these ratios. He concluded that the model for his data which was collected for 51 pairs of failed and non-failed companies in the UK, could accurately classify 82% of the companies in the year prior to bankruptcy, 88% two years prior, 76% three years prior and 62% four years prior. The four models developed were:

$$Z_{T-1} = 4.493X_{10} + 3.126X_{11} + 4.041X_{16} - 13.087X_{18} + 462X_{19} + 0.231X_{23} - $$
$$-2.576$$

$$Z_{T-2} = 4.865X_{10} + 0.025X_{15} + 1.485X_{16} - 11.151X_{18} + 5.662X_{21} + 3.608X_{23} - $$
$$- 1.413$$

$$Z_{T-3} = 1.813X_{9} - 0.075X_{4} + 3.329X_{14} - 2.116X_{17} - 2.435X_{19} - 0.0001X_{24}$$
$$- 1.073$$

$$Z_{T-4} = 3.508X_{13} - 0.009X_{15} - 3.536X_{17} + 0.752X_{20} + 2.538X_{23} - 0.0001X_{24}$$
$$- 2.252$$

Z_{T-N} indicates the year to which they refer.

It is felt that the empirical results obtained in the course of study by different authors strongly suggest that it is possible to predict the occurrence of company failure prior to the event with some level of accuracy (Altman, Taffler, Hawkins, Townsend, etc.). Table 2.3 shows the comparative predictive ability of models developed by the authors. Table 2.4 shows the ratios which are good discriminators between failed and non-failed companies in multivariate studies.

Since it is clearly possible to predict with a good degree of accuracy the failure of a company purely from an analysis of its published and equity data up to four years prior to the event, it is perhaps surprising that more firms do not take appropriate remedial actions in good time, or conversely are still predicting recovery even one year before their entry into liquidation. This is further evident from the study of the causes and symptoms of failure by the author which showed in almost all the cases the chairman's statements and annual reports were misleading and grossly incorrect based on manipulated accounts and window-dressed balance sheets to

TABLE 2.3 Comparative Predictive Ability of Models Developed

YEAR	Per Cent Correct Classification				
	Altman	Townsend		Hawkins	
	Primary	Primary	Secondary	Primary	Secondary
T-1	95	92	100	87	82
T-2	72	80	100	81	88
T-3	48	80	80	79	76
T-4	29	-	-	76	62
T-5	36	-	-	-	-

Sources: Altman, E I - Corporate Bankruptcy in America
Townsend, T G - The Characteristics of Corporate Death
Hawkins, J W - The Dynamics of Corporate Death

TABLE 2.4 Ratios shown to be Good Discriminators between Failed and Non-Failed Companies in Multivariate Studies

Author and Year of Publication	Tamari 1964	Altman 1968	Edminster 1972	Blum 1974	Gru 1973	Townsend 1978
Current Asset and Liability Rates						
Current	x					
Quick (Firm/Industry Average)			x			
Net Quick Assets/Stock				x		
Trend Breaks of Net Quick Assets/Stock (a)				x		
Earnings before Interest and Taxes + Depreciation/Total Debt					x	
Capital Structure Ratios						
Net Worth/Total Liabilities	x					
Reserves/Total Assets		x				x
Current Liabilities/Net Worth			x			
Market Value of Equity/Total Liabilities (b)		x				x
Total Debt/Total Assets					x	
Asset Structure Ratios						
Working Capital/Total Assets		x		x	x	x
Net Profit Ratios						
Profit before Interest and Taxes/Total Assets		x			x	x
Profit Trend	x					
Rate of Return on Equity (b)				x		
Cash Flow Ratios						
Cash Flow/Current Liabilities			x			
Cash Flow/Total Debt				x		

TABLE 2.4 (Contd)

Author and Year of Publication	Tamari 1964	Altman 1968	Edminster 1972	Blum 1974	Gru 1973	Townsend 1978
Sales and Cost of Sales Ratios						
Stock/Sales			x			
Sales/Total Assets		x			x	
Net Worth/Sales			x			
Working Capital/Sales			x			
Sales/Debtors	x					
Value of Production/Stock (c)	x					
Value of Production/Working Capital (c)	x					
Other Data						
Number of Ratios Tested	10	22	14	12	21	5
Number of Failed Companies Studied	28	33	21	115	34	35
Years in which Failures Occurred	1958-60	1946-65	1958-65	1954-68	1965-67	1967-75
Country Studied	Israel	USA	USA	USA	USA	UK

(a) A trend break is defined as any performance by a variable less favourable in one year than in the preceding year
(b) These are the only ratios referred to here that are not calculated wholly from accounting data.
(c) Value of Production = sales + change in stocks of finished goods and work in progress.

Adapted from Dev. S., 1974 and Townsend, T G., 1978

It is the author's opinion that the ratios in the above table can be of value to future researches in financial analysis of companies.

conceal the facts.

The financial analysis of companies has been carried out to develop failure prediction models to spot potential failure. There are many arguments that these models do not project the intervening economic conditions (Johnson, 1970)[90]. The authors defend their models by arguing that all these economic conditions are projected through the financial ratios as variables (Altman)[4]. They believe that the models do not contain information about the alternative strategies, but one has to bear in mind that models were not intended to do so. They were for the purpose of finding those companies at risk (Taffler)[144] by an appropriate combination of certain ratios. Briefly, they do not analyse, they just simplify the job of analysts and those interested groups to pay more attention and time in identifying the underlying causes and problems whose outcome is a low Z score.

These models are particularly advantageous to bankers, investment analysts, creditors, stockbrokers and other corporate interest groups. It is also useful to the management of the company.

The term 'prediction' does not mean when a company will fail in a particular time in the future. The prediction models in the field of business are more definitional rather than predictive in a conventional form as they measure the propensity of failure and not the actual failure date. They classify companies according to their financial characteristics resemblance to the previously failed companies to identify whether they are in danger area and risk or not. The actual failure depends on the severity of difficulties, management ability and will to recognise the weaknesses and take the corrective actions or otherwise, and many other factors including those outside management control e.g. external factors.

Ratios are constructed from accounting data which are subject to different interpretations and even manipulation. For example, two firms may use different depreciation methods or inventory valuation methods; depending on the procedures followed, reported profit can be raised or lowered. Similar differences can be encountered in the treatment of research and development expenditures. Ratios are extremely useful tools, but as with other analytical methods, they must be used with judgement and caution. Nevertheless, even with the selection of right ratios and supplementary information one cannot place absolute reliance upon the results of financial ratio analysis and do not take the position that predictive models based on these ratios are the answer to evaluating the performance of a firm, but they are a powerful tool to provide a basis for raising questions and further investigation and analysis. They can be used as indicators and warning systems to management and analysts in order to develop first hand knowledge of the operations of the company and a sense, a touch, a smell, and a feel of what is going on in the firm. Sometimes it is this sixth sense kind of business judgement that untangles the causes of failure and uncovers the weaknesses in the firm.

Although it is believed that models predicting failure can be self-fulfilling[149], the question is whether or not users of such models are able to accurately interpret any information the models may provide. Both Kennedy (Kennedy, H A, 1975) and Libby (Libby, R, 1975) have described experiments designed to test the ability of analysts to correctly interpret accounting information. Their conclusions were that the usefulness of accounting information is a function of the predictive ability of the information, and the ability of users to interpret the data.

Finally, the author believes that although 'Age' has been named as an important variable in failure prediction models and almost all the authors are shared with Altman that "Age variable, or a proxy for age, would be a prime measure to utilise in a bankruptcy prediction model", none of them included this variable in their models. This might be of interest to investigate the possibility of adding the probability of company failure based on their age structure in order to improve the accuracy of the models and their application, specially for insurance companies which are always interested in age characteristics of individuals and firms.

2.3 Non-Financial Analysis

Although the information necessary to diagnose causes of failure varies from case to case and is not readily susceptible to statistical generalisation (Blum)[24], it is important to integrate this with those provided by the predictive models and financial analysis of companies.

A model that can be useful in the prediction of business failure must have a theoretical foundation. This foundation establishes the relationship between the model and the event which is to be predicted. Without such a foundation, the model may not be fundamentally related to the event which is to be predicted,- business failure. If there is no rationale for a correlation between model and event, there is little faith that the model would continue to have predictive power, even though it may have worked well on past occasions (Blum)[24]. The causes of failure could be viewed, in part, as dbverses of causes of success . It should be noted that business failure prediction models will not under normal circumstances be the physician and panacea to the sick patient (Altman)[4]. It merely serves as objective quantification of the patient's illness but it cannot point directly towards the areas of most pressing need. Once management is convinced of the immediate need for change, then it is his responsibility to implement these new business policies which will either save the company, or hasten its death. The latter choice can be extremely important to the present creditors and even the owners. The corrective actions cannot be

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Kelly and Lawyer(94) believe that "success, failure, or merely average achievement in small businesses depends more on the individual than upon anything else." They conclude, "Business failures are human failures, as are those in most other lines of activities."

Broom and Longenecker(30) state "The threat of failure confronts many small business enterprises, particularly those that are newcomers." In the analysis of causes of failure they suggest that aside from the relatively few failures caused by fraud, neglect and disaster, the root cause is found in managerial incapacity, and other more prominent difficulties are the following:

Competition

Lack of capital

Location

Premature expansion

They also refer to the symptoms of business failure, explaining that the following types of change are symptoms of impending business failure:

1. Deterioration of working capital position
2. Declining sales
3. Declining profits (or increasing losses)
4. Progressively higher debt ratio.

R D Bullock(35) in an attempt to give the symptoms of sickness in small firms writes "There are the signs to watch: lack of any plan for the future, the company reacting to events as they occur, a chronic shortage of working capital, payments to suppliers or even payrolls are delayed unti- cheques arrive from customers, low employee morale, frequent absenteeism, high turnover, low profits or none at all because sales are weak and not growing, costs higher than expected, chronic late shipments, poor work scheduling, lack of timely or adequate management information and poor intra-company communications." He also comments on other factors and carries on his list as: "Executives who work overtime, guesswork pricing, too much reworking of products after final inspection, desks piled with the paperwork showing either inefficiency or insufficient office staff." The author believes that, although most of the items in this list can be seen in a weak organisation, they are not in any particular arrangements.

M Allsopp(3) quotes "As with ships, businesses are usually lost because of errors of navigation, command and control rather than through inherent faults in the vessel." He further comments that any malfunction capable of bringing a company to grief has its counterpart in a board weakness and frequently in the managing director himself. There is nothing more potentially dangerous to a company than self-satisfied leadership, confident that the size of the business, the established supremacy of its position or its name alone will ensure continued profitability. Allsopp believes that for the most causes of failure one must look at the board, its composition-balance and bias, the calibre of the board in times of difficulty and also the managing director and purpose of the company. He concludes "To summarise, the responsibility of the board is inescapable and that of the managing director complete. Each board must assemble a blend of skills that are appropriate to its activities and challenge and change its composition as necessary to anticipate changes in the demands made upon it. Imbalance or inadequacy in the board may produce a fatal counterpart in the organisation as a whole."

ARGENTI (Argenti, J, 1976)(11)

Argenti is one of the first authors in the UK who has contributed on the subject of corporate failure in detail and has attempted in his book 'Corporate Collapse' to bring together an extensive collection of knowledge and experience on the early identification of failure and its prevention and cure.

This study is based on the conclusions of previous researchers in the United States and United Kingdom plus a few interviews which are given in detail to the readers in different chapters. Having presented a synopsis of the views of a considerable number of writers and experts in this field, he reproduced a list of causes and symptoms of failure, and presents a list containing twelve items (in italics) as his list which he believes are linked together in a mechanism that operates as follows:

"If the *management* of a company is poor, then two things will be neglected: the system of *accounting information* will be deficient and the company will not respond to *change*. (Some companies even well-managed ones, may be damaged because powerful *constraints* prevent the managers making the responses they wish to make). Poor managers will also make at least one of three other mistakes; they will *overtrade*; or they will launch a *big project* that goes wrong, or they will allow the company's *gearing* to rise so that even *normal business hazards* become constant threats. These are the chief causes, neither fraud nor bad luck deserve more than a passing mention. The following symptoms will appear: certain *financial ratios* will deteriorate but, as soon as they do, the manager will start *creative accounting* which reduces the predictive value of these ratios and so lends greater importance to *non-financial symptoms*. Finally the company enters a characteristic period in its *last few months*.

D Cohen(44) begins his article "Confidence comes before a crash" by writing "Spectacular business crashes like Rolls Royce and Vehicle and General have made it uncomfortably clear that no firm is above economic law. They suggest that many managements are reluctant to recognise the increasing vulnerability of business life." The most obvious danger signals given by Cohen is said to be the result of discussion with many company doctors which are as follows:

1. Liquidity problems.

They may indicate that the business as a whole is not doing well or that a key department is failing to pay its way.

2. Interest rates.

Many businesses accept rates which lead to a situation where they have to borrow money to pay off their debts - double interest.

3. Credit control.

This is one of the factors contributing to liquidity problems. Three points are essential here:

Do not borrow too much

Do not lend too much

Do not pay too much for your own credit

4. Technological bakcground.

Lack of product innovation and response to technological change is another signal for the weak companies.

5. Prestige over profit.

Expensive offices in central city, travelling by first class tickets, expensive business lunches and this kind of luxury spending are symptoms of companies which try to put prestige over profit.

6. Recruitment.

A tendency to recruit those who conform to managers' own prejudices and hiring people in their own image is another sign of weakness.

7. Relying on too few accounts.

Reliance on too few accounts and customers means putting the business at risk. Once you lose the big customer you may find that a large part of your business can simply disappear.

8. Growth

Although one might not totally agree with the philosophy of Growth Stock that "if you are not growing, you are stagnating", what is true is that a company that does nothing more than maintain a certain level of profit is exposing itself to takeover.

9. Over-expansion

Uncontrolled over-expansion is dangerous.

10. Industrial Relations

The final sign is to understand, think and treat the employees as individual people and not as numbers.

P W J Hartigan[75] in an article 'Causes of Company Failure', states that "Many business failures are the result of surprisingly obvious human failings." In this article, in which the writer draws on his own professional experience, an attempt is made to analyse the main causes of insolvency. The most common causes of failure found, based on experience of dealing with insolvent companies over years, were:

Lack of capital

Undercosting

Lack of management control

Lack of adequate advice

Government restrictions

Trade fluctuations

Fraud

Hartigan describes each factor in detail and concludes that "Most cases of failure involve several of the above factors, the most common combination being lack of capital and inadequate management control. Some factors not already mentioned can be found. The human elements: greed, stubbornness, dishonesty have a major part to play in many failures, but pervading them all is inability or unwillingness to see the facts."

R Brough (31) in a study of 100 private companies, wound up compulsorily under English Law in 1975, shows the principal causes of failure in the opinion of the Official Receivers and Directors as follows:

A. Principal Causes of Failure in the Opinion of Official Receivers

Mismanagement	67
Insufficient Capital	31
Insufficient working capital	20
Excessive remuneration to, or drawing by Directors	7
Inadequate accounting	5
Inexperience	5
Gross management	4
Bad debts	4
Under-estimating	4
Pilfering or fraud	4
Over-trading and expanding too rapidly	3
Increasing overheads	3

B. Principal Causes of Failure in the Opinion of Directors

Insufficient working capital	28
Insufficient capital	23
Bad debts	18
Inexperience	10
Poor labour and poor supervision	10
Keen competition	9
Ill-health	9
Under-estimating	7
Too rapid expansion	6
Stortage of materials	4
Bad weather	4
Pilfering or fraud	4
Inadequate accounting	3
Increasing overheads	3
Customers dissatisfied	3
Let down by customers	3

As can be observed, the Directors of the failed companies offer a greater variety of reasons for their lack of success than did the Official Receivers.

Chris Baker(12), a financial analyst and specialist points to budgetary control, cash flow and an effective costing system as being major factors in ensuring whether a company survives or fails. He also is concerned that "with decisions now having to be taken which will virtually affect the future of many companies, there are many boards where the skills possessed by directors are unbalanced, and too many smaller companies lack a strong finance director and possess little in the way of professional management below board level."

A J Towlson[150] describes business failure as a gradual process, often over many years, which is preceded by a long and intense struggle to improve profit and/or cash performance. He quotes "The symptoms of existing, or impending, collapse may be obvious." The most usual and significant signs include:

Total dependence on short-term finance

Lack of liquidity identified by slow payment of accounts, excessive stock of debtors

Delayed presentation of annual accounts

Management strife and changes

Same trade/industry failures

Same group failure.

He views the failure to arise from management ineptitude, inexperience, or lack of foresight. The main internal factors which give rise to collapse are:

Poor financial planning and control

Inadequate marketing

Ineffective management organisation

Inadequate production facilities

Overtrading

The main external factors are industry and social trends, economic and financial conditions, technological obsolescences and government policy and legislation.

A Rapazzini[122] comments that "companies spotting the possibility of greater profits in some markets, may diversify into fields with which they are not familiar. A particular problem which arises here is that the danger signals in an unfamiliar market are that much more difficult to recognise. They are just not aware of the critical control aspects."

He sees companies as being weak as ever in the provision of management reporting systems. A simple financial reporting system should cover three main areas; cash flow, trading summary and balance sheet.

J E Ross and M J Kami[124] define the nature of the crisis in management and demonstrate how selected companies in a number of industries have managed to mismanage their affairs. Finally they include a check-off list for a self-audit on the management of company. The general conclusion of this study which is given in the first chapter of their book is named "The Ten Commandments of Management" as follows:

1. Develop and communicate a strategy ..... a unified sense of direction to which all members of the organisation can relate.
2. If you want to achieve plans, programs and policies, then overall controls and cost controls must be established.
3. Exercise care in the selection of a board of directors and require that they actively participate in management.
4. Avoid one-man rule.
5. Provide management depth.
6. Keep informed of change and react to change
7. Do not overlook the customer and the customer's new power.
8. Use, but do not misuse, computers.
9. Do not engage in accounting manipulation
10. Provide for an organisational structure that means the need of people.

They go through each of the above items, considering successful and unsuccessful companies, illustrate how these commandments were broken or ignored by failed firms.

J Van Horne[154] who devotes one chapter of his book to business failure and re-organisation, expresses his view as "Although the causes of financial difficulty are numerous, many failures are attributable either directly or indirectly, to management. Usually non-financial problems lead to losses which, in turn, lead to financial strain and eventual failure. Very seldom is one bad decision the cause of the difficulty. Usually the cause is a series of errors, and the difficulty evolves gradually."

Van Horne comments that "the remedies available to save a failing company vary in harshness according to the degree of the financial difficulty. If the outlook is sufficiently hopeless, liquidation may be the only feasible alternative."

Dun and Bradstreet[58] which provides one of the most comprehensive USA business failure statistics, tabulates and reports failure causes based on opinions of informed creditors and information in credit reports.

As can be observed from Table 2.5 over 90% of all failures result from one type of management inefficiency or another. This table breaks down the causes of business failure into its components as well as percentage presentation of causes. It should be noted that because some failures are attributed to a combination of apparent causes, percentage does not add up to 100%. The principal weaknesses of US unsuccessful businesses, given by Dun and Bradstreet, are

Inadequate records

Inaccurate costing information

Insufficient long-term capital

Failure to budget expenses

Excessive operating costs

Little or no internal control of expense

Faulty purchasing procedure

Faulty sales policy

Lack of stock capital

Lack of effective credit policy

Excessive investment in plant

Table 2.5 Business Failure by Cause in 1969 (USA)

APPARENT CAUSES	Wholesalers	Retailers	Construction	Commercial Services	Manufacturing	All
Neglect	3.3%	2.8%	3.2%	2.9%	2.0%	2.8%
Fraud	2.0	1.1	0.9	0.9	1.1	1.2
Inexperience & Incompetence:						
Inadequate Sales	43.4	39.7	30.3	38.3	43.9	39.0
Heavy operating expenses	9.0	8.4	14.1	13.7	14.7	11.2
Receivables difficulties	14.8	3.4	17.9	6.0	15.5	9.3
Inventory difficulties	6.3	6.5	0.6	0.9	3.3	4.2
Excessive fixed assets	1.5	2.7	3.5	4.4	6.7	3.6
Poor location	0.7	5.0	0.2	1.7	0.3	2.6
Competitive weakness	20.4	22.1	25.3	17.0	18.3	21.2
Other	1.4	1.4	1.8	0.8	1.7	1.4
Disaster	2.3	1.8	0.3	0.5	1.7	1.4
Reason Unknown	4.3	7.2	6.9	14.1	3.4	7.1
TOTAL NUMBER OF FAILURES	842	1070	1590	1159	1493	9154

Source: Dun and Bradstreet, Inc. The Failure Record Through 1969 (New York, 1970), pp. 11-12

Classification of Business Failure based on Opinion of Informed Creditors and Information in Credit Reports

Dewing[54] who is one of the earliest authors in writing and analysing corporate structure, refers to failure in Chapter Two of his book. Commenting "The term 'failure' is used lossely in the writings of business and in the literature of economics. Broadly speaking a business is an economic failure when the net return on capital invested, after an allowance has been made for the risk involved, is distinctly less than the prevailing interest rate on capital. A corporation which owns a business is a legal failure when there is not available sufficient money to meet the legally forcible demands of creditors."

Dewing believes that there are four fundamental economic causes of failure of large businesses. They are:

1. Excessive competition
2. Unprofitable expansion
3. Change in the public demand for the commodity
4. Distribution of capital as ostensible profit.

In a broad sense all of these are different phases of the single all-embracing causes - lack of skill of management. It is the lack of skill in meeting excessive competition, lack of skill in undertaking programmes of expansion likely to prove disastrous, lack of skill in foreseeing a change in public demand and in not adjusting the business to this change, and the lack of skill in conserving the capital within the business.

In the same chapter, Dewing states "Whatsoever the fundamental causes that lie back of corporate failure, other and more superficial causes are usually advanced by corporate officials as plausible explanation. The operation of causes is obscured by many subordinate considerations. The corporation struggles to avoid confessing failure. At first it sells stock or long time bonds, covers up the losses by accounting methods and as failure becomes more threatening the corporation sells short-term notes or increases its indebtedness to the banks and finally when the obligations become so great and there is no more alternative the corporation confesses its insolvency with a big excuse - lack of current capital.»

Another study in this area is the one carried out by Dun and Bradstreet in 1965. Table 2.6 gives the causes of business failure based on both Official Receivers and Directors of US failed companies which is of great interest for comparison of views. Naturally, one would expect that the Directors' or the owners' enumeration would look quite different. The true answer to the question - "What was the primary cause of failure ?" - is probably much closer to the creditor opinion, although even here there is undoubtedly some bias built into the results.

These causes arise from both internal and external conditions and it has been estimated that nearly 90% of insolvencies are due to internal failures. It is interesting to note that while 67 offical receivers suggest mismanagement as an important cause of failure, there is no indication of this factor as failure by the directors. Having considered the table one can realise that directors, however, accept their lack of competence, ability and efficiency by giving their views on factors such as: poor labour/poor supervision, keen competition, bad debts, underestimating, insufficient capital and working capital. In actual terms what they suggest are the symptoms of underlying causes which is poor management, mismanagement and bad management.

H LEVY and M SARNAT in an analysis of the nature of financial failure state: "The usual causes given for financial failure, e.g. lack of capital, faulty accounting, poor planning, etc., are more often not causes but rather rationalisations or excuses for the poor performance. The underlying cause of most failures can best be summarised by the term management incompetence. It is the lack of managerial skills which appears to be the

Table 2.6

Causes of Business Failure - 1965

Causes of Failure	Official Receivers' Opinion	Directors' Opinion
Mismanagement	67	-
Insufficient capital	31	23
Insufficient working capital	20	28
Poor labour/Poor supervision	-	10
Keen competitors	-	9
Ill health	-	9
Excessive remuneration/drawing	7	-
Inadequate accounting	5	3
Inexperience	5	10
Expansion too rapid	-	6
Gross management	4	-
Bad debts	4	18
Under-estimation	4	7
Pilfering/Fraud	4	4
Shortage of materials	-	4
Bad weather	-	4
Overtrading/expansion too rapid	3	-
Increasing overheads	3	3
Customer Dissatisfaction	-	3
Let down by customers	-	3

Source: Dun and Bradstreet (1965 Survey) fundamental cause of business failure, independent of the size or nature of the business undertaking. Ultimately, business success or failure depends on the quality of human management."

H G GUTHMANN and H E DOUGLAS(72) in an analysis of failure causes, stress that the causes of failure may emerge in every phase of the business activity, and "since the type of remedy or treatment applied should depend on the diagnosis, it is important to recognise where the main difficulty lies. Regardless of whether the cause of failure is financial or non-financial in origin, failure is indicated by a financial condition which calls for adjustment, and the problem of cure will rest largely with financial management."

They divide the causes of failure into two groups; internal and external causes and also on a functional basis - that is, according to the department of the business in which the troublesome weakness arise. Their classification of failure causes can be summarised as:

1. Internal Causes

   A. Financial

      1. Excessive funded debt

         (a) Initial

         (b) Subsequent to promotion

      2. Excessive current debt

      3. Slow collections or bad debt losses

      4. Unwise divided policy

      5. Inadequate provision for maintenance and depreciation

   B. Non-Financial

      1. Unwise initial promotion

      2. Weak purchasing policies

      3. Poor production policies

      4. Unskilful marketing policies

5. Inventory losses
6. Unwise expansion
7. Fraud

II. External Causes

1. Excessive competition
2. Changes in public demand
3. The business cycle
4. Political
    (a) Excessive taxation
    (b) Hostile regulations
    (c) Adverse tariff legislation
5. Foreign and special factors
6. Accidents of nature (Acts of God)

They describe the more important factors and conclude that whatever the cause of failure may be, every effort should be made to preserve the company as a going concern.

A WYRCAN(163) in an article "Under British Management" gives a few of the danger signals he spotted when he joined a small firm which was in trouble. He quotes "A complete disregard by practically everyone in the works and offices of the top man's presence. Conversation and/or inactivity continued quite unaffected in our presence. Many of those who were working stopped to appraise the'visitor'. The area in front of the stores was like the Law Courts' Bear Garden, the babble among the groups gathered there was extraordinary and continued unabated and unabashed. Gangways between benches and machines were cluttered, filth and rubbish lay everywhere ardund machines, benches and the yard. There was not a production engineer in the firm." These signs are more or less good evidence of the existence of some problems which can be very important to those who are able to recognise

PAGE
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AS ORIGINAL

troubles from the symptoms and this can be obtained through a tour of the premises.

E Y DERAN( ) in a study of 333 small firms in nine communities in Illinois arrived at the following conclusions: "If the reasons are grouped into the four very broad classifications of personal qualities, financial policies, non-financial business policies and exogenous factors, then it turns out that the most frequent explanation for business failure is various defects in personal characteristics of the owner, ranging from a grumpy personality through addiction to wine, women and song. Such personal explanations accounted for 36% of the factors listed as the primary cause of failure and 33% of all causes. Faulty financial policies were the second most important - 34% of both the primary and all causes. The three exogenous factors of poor location, vigorous competition and changes in retailing trends accounted for 20% of the primary reasons and 15% of all reasons. Non-financial policies ranging from poor merchandising through labour problems, represented only 9% of the primary causes but 18% of all causes."

An analysis by E E BARBEE[13] concludes that "80 to 90% of failures are directly traceable to the man who fails."

Woodruff and Alexander[162] conclude in their study of ten 'successful' and ten 'unsuccessful' small firms:

1. None of the unsuccessful firms had already good financial records and nine of them had extremely poor records, so that management lacked navigation aids through the business shoals and mudbanks. All of the ten successful companies, in contrast, had well-informed managements, kept complete records and made full use of the records that were kept.

2. All of the unsuccessful firms, with no exceptions, regarded selling as a nuisance. On the other hand, all of the successful firms emphasised

selling.

3. Very few of the unsuccessful firms paid any recognisable attention to research and product development. On the other hand, nine of the ten successful ones emphasised the importance of such activities.

4. All of the unsuccessful companies showed inept internal administration. In successful groups lines of authority were clear.

D CHILVERS[40] who has investigated many companies in trouble expresses his view as "Bad management must be at the top of the list. If one is looking for another common cause of a company's downfall, it will be that it has over-committed itself - usually by trying to diversify in an expensive or over-ambitious fashion. In such cases the basic error of under-capitalisation might be compounded by a chaotic approach to debt collection, or a reluctance to quote selling prices at an economic level, or a general failure to exercise discipline over the incurring of capital commitments. In short, little attention may have been paid to cash flow."

He also comments on the symptoms of trouble by "A common symptom in a crisis torn companu is inadequate or misleading management information at board level." He believes that there has always been either a total failure to bring information to the attention of the board, or alternatively, failure on the part of the board to act on the information.

Sir Charles Hardie[74], a senior partner of an accountancy firm, sums up his experience of handling many receiverships as "There are certain patterns of corporate behaviour which are fraught with potential dangers." What is more, he believes that directors could often do more to alert themselves to the dangers at an early stage. The slippery path to bankruptcy is not so clearly marked out, but often the signs are there to be seen. The trouble, he comments, is that "it has become such a habit that boards do not think as carefully as they should." His message is to have a list of all items at risk at any one time which "enables proposed projects to be examined in perspective against the backdrop of its total risks, otherwise boards tend to evaluate in isolation."

Kenneth Cork[46] is another expert in receiverships and company failure who emphasises communication as an important cause of failure by quoting "... With businesses which get into difficulty, so often the key problem is communication. I am struck by the inability of so many companies that get into difficulty to communicate, even with themselves, let alone with their staff." This is a great failure, he adds, and accountants are responsible for some of it. "A person can only think with the information he has in his head. If the management have a mass of figures coming up to them of accounts, costings, forecasts and everything else, things are so complicated that they cannot absorb them." A lot of trouble is due to complicated figures being produced.

With regard to danger signals, he comments "The one who gets into difficulties is usually an optimist. As things get difficult the human mind cannot take bad news endlessly; so even if the information is there, he shuts his eyes and would not look at it." Cork also refers to the chairman's statement with the optimistic comments when the company is doing badly and says "Yet if you look at the balance sheet you can see that he has no more assets to pledge, the bank overdraft is at the limit. So if he does get the turnover, he will undoubtedly go broke." There is an interesting reference to some symptoms of failure when Cork stresses, "Often when you open the top right hand drawer, there is a whole pile of unopened letters - unopened because the person could not read them; it made him feel ill to read them. Instead, he took refuge in working 14 hours a day, rather than think."

One of the recent studies which has been conducted by the Centre for

Interfirm Comparison(38) identifies the factors which distinguish successful businesses from unsuccessful ones, and shows that managerial characteristics are related to success and failure. The main findings of the study are that firms with better performance (measured by return on assets) can be distinguished by differences in a number of detailed performance measures. The most important of these is profit margin, which emerged as the chief determinant of success. Other findings are:

1. A well-defined production policy is more important than new machinery.
2. Stock and debtor control are vital in manufacturing industries.
3. The systematic professional management is more likely to lead to success than haphazard management.

This study suggests some key features associated with success of companies.

K S Lomax(104) in an attempt to analyse the business failure data draws attention to business mortality theory and quotes "It is fairly well established that with most types of business the early years are the most difficult. It is then that mortality is highest. The longer a business survives, generally, other things being equal, the smaller becomes the probability of failure."

Lomax takes the data compiled by R G and A R Hutchinson and Mabel Newcomer(86) to calculate F(t), for different values of t, where

F(t) = cumulative probability of failure in the interval (0,t).

f(t) = probability density function of failure time

He also calculated the values of Z(t) which is called the conditional density function of failure probability with time, in other words, the instantaneous probability rate of failure at time t conditional upon non failure prior to:

$$Z(t) = \frac{f(t)}{1-F(t)}$$

The values are given in the tables. He concludes that "It is of interest to record that a good fit to the Z(t) values can be obtained, in each case, either by the exponential function."

$$Z(t) = a\,e^{-bt}$$

or the hyperbola

$$Z = \frac{b}{t+a}$$

He interprets that for manufacturing businesses the exponential gives better fit.

The weakness of this analysis is mainly due to the lack of data for a longer period and a high percentage of failure shown in the first year of company life which is open to question. The data cannot represent the industries in general as they were compiled for a small town in the period 1844 to 1922 in America. Lomax realises the weakness and stresses "I hope shortly to carry out a more detailed analysis of business mortality covering British as well as American data. A cursory examination has already indicated that British experience does not always completely accord with American."

The author believes that a better conclusion can be made if one takes Table XII of the same data source which gives the length of life of common corporations and all forms of business enterprises.

R G and A R Hutchinson and M Newcomer[86] in a study of the length of life of business enterprises in Roughkeepsie, New York during 1843-1936, provide one of the most comprehensive data for business mortality analysis. They present tables for the length of life for different industries and according to two assumptions:

1. Not counting change in proprietorship as a New Business
2. Counting change in proprietorship as a New Business

Tables 2.7 and 2.8 give the percentage distributions of business life

Table 2.7

Length of Life of Business Enterprises Established in Poughkeepsie between 1844-1926
Not Counting Change in Proprietorship as a New Business

AGE	Retail		Wholesale		Manufacture		Craft		Service		Total	
	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.
1	29.6	1479	19.7	31	23.1	218	30.7	404	32.7	856	29.8	2990
2	14.2	710	9.6	15	11.5	109	14.7	193	13.0	340	13.6	1364
3	9.4	470	8.3	13	12.3	116	9.7	128	9.4	246	9.7	973
4	6.2	310	8.3	13	7.8	74	5.6	74	6.7	175	6.4	642
5	4.9	245	5.1	8	5.5	52	5.3	70	5.1	133	5.0	502
6	4.1	205	5.1	8	5.3	50	3.7	49	3.9	103	4.1	411
7	3.1	155	5.7	9	2.3	22	3.0	39	3.5	92	3.2	321
8	2.6	130	3.2	5	2.4	23	2.6	34	2.6	68	2.6	261
9	2.1	105	2.5	4	2.4	23	1.9	25	2.3	60	2.2	221
10	2.0	100	1.3	2	2.0	18	1.9	25	2.0	53	2.0	201
Over 10	21.8	1089	31.2	49	25.3	239	20.9	274	18.8	492	21.4	2147
TOTAL	100	4998	100	157	100	945	100	1315	100	2618	100	10,033

Table 2.8

Length of Life of Business Enterprises Established in Poughkeepsie between 1844 and 1926
Counting Change in Proprietorship as a New Business

Age	Retail %	Wholesale %	Manufacture %	Craft %	Service %	Total %
1	32.5	22.4	24.0	31.9	32.9	31.5
2	13.3	9.8	13.1	14.8	14.3	13.7
3	9.2	11.5	12.7	9.8	9.6	9.8
4	6.1	8.2	8.0	6.2	6.9	6.5
5	5.1	6.0	5.4	5.4	5.3	5.2
6	4.2	6.6	4.5	3.7	4.0	4.2
7	3.1	5.5	2.7	3.1	3.3	3.2
8	2.8	1.6	2.9	2.5	3.0	2.8
9	2.3	2.2	2.7	2.2	2.2	2.3
10	2.2	1.1	2.7	2.2	1.9	2.1
Over 10	19.3	25.1	21.4	18.1	16.6	18.7
TOTAL	100	100	100	100	100	100

Table 2.9

Comparison of Length of Life of Corporations and All Forms of Business Enterprises, Poughkeepsie, 1844-1926
"Cumulative Percentage Distribution"

AGE	RETAIL		WHOLESALE		MANUFACTURE		CRAFT		SERVICE	
	All Concerns	Corporation	All Concerns	Corporation	All Concerns	Corporation	All Concerns	Corporation	All Concerns	Corporatio
1	30	20	20	10	23	10	31	0	33	23
2	44	32	29	30	35	26	45	0	46	37
3	53	44	38	30	47	40	55	0	55	43
4	59	52	46	30	55	48	61	0	62	49
5	64	58	51	40	60	55	66	0	67	52
6	68	63	56	40	66	63	70	0	71	52
7	72	65	62	40	68	69	73	0	74	57
8	74	66	65	50	70	73	75	33	77	57
9	76	68	68	50	73	75	77	33	79	66
10	78	69	69	50	75	76	79	33	81	69
Over 10	22	31	31	50	25	24	21	67	19	31
TOTAL	4998	117	157	10	945	108	1315	3	2618	35

based on the above assumptions.

The striking figures in these tables are a very high mortality in the first year which means 30% of business enterprises started during the period of study failed to reach their second year. When the duration of a business enterprise is assumed to end with any change in proprietorship, the average length of life is somewhat diminished.. The number of concerns that fail to live a second year rises from 29.8% to 31.5% and the number living beyond the tenth year falls from 21.4% to 18.7%. Comparing the data in both tables shows that the wholesale businesses have the best record for longevity and the service enterprises the poorest record.

The author concludes that Table XII of this study, which is given as Table 2.9 here, would provide better information for the comparison with other studies and analysis of company failures. As can be observed, the percentage of corporations surviving the first years exceeds that for all forms of organisation. The proportion of corporations that survive ten years is also greater than that for all cases, except manufacturers, which is slightly smaller than all. The final conclusion made is "The high mortality which has been found to exist among Poughkeepsie business enterprises unquestionably represents serious economic wastes .... The nature of the study prevents any adequate analysis of causes of the high mortality, but small capital, lack of experience, and overcrowding are all indicated - the high mortality is the price of a laissez-faire system."

A study by the University of Buffalo (1930, p.51) of retail trades in Buffalo, 1918 to 1927, concludes that "The number surviving the first year was only 40% of those entering the grocery business, 56% for shoe stores, 65% for hardware, 73% for drugs." The result of this study supports the idea that the chances of survival are progressively improved after the initial year.

R P BROOKER and T M F SMITH[29] in a study of English insolvency statistics take a sample from those companies which commenced to wind up in 1956, comprising:

	No. in sample
Creditors' voluntary winding up	340
Winding up by order of court	100

Only five companies in the sample are not private companies. The opinion of Official Receivers as to the causes of failure are quoted as "Lack of capital and mismanagement. Mismanagement (sometimes emphasised by the epithet 'gross') is often particularised as a failure to control some sort of expense. In only two companies has competition been mentioned as a cause of failure. The overall impression conveyed by the causes of failure is one of ineptitude and folly on the part of the directors." Referring to the reasons of business failure in England, they comment "This implies that a large proportion of those businesses in the insolvency statistics would have failed in any economic climate; it also suggests that many businesses are only marginally surviving at any one time. These businesses may be doomed but the speed of their death should be determined by the state of the economy."

From the previous sample and 169 companies struck from the register without liquidation where a receiver had been appointed in 1955, they give an estimate of length of life of companies (Table 2.10). The length of life of companies wound up by order of court in the High Court and their cumulative percentage of companies are also given in Table 2.11 for the years 1896, 1906, 1926, 1936 and 1956. As can be observed from the table 31% of companies failed after 3½ years, 43% after 5½ years and only 40% of companies survived more than 9 years.

Table 2.10 Length of Life of Companies entering into Insolvency process in 1956 in England and Wales

Length of Life in months	Percentage of Companies Failing	Cumulative Percentage
1 to 6	-	-
7 to 18	12	12
19 to 30	9	21
31 to 42	10	31
43 to 54	5	36
55 to 66	7	43
67 to 78	2	45
78 to 108	15	60
Longer	40	100
TOTAL	100	

Table 2.11 Cumulative Percentage of Companies Wound Up

Length of Life in months	1896	1906	1926	1936	1956
1 to 6	7	1	3	4	-
7 to 18	33	30	26	32	13
19 to 30	55	53	43	55	25
31 to 42	62	66	56	66	37
43 to 54	69	73	61	75	42
55 to 66	78	77	63	79	49
67 to 78	85	81	68	81	50
79 to 108	92	85	76	85	67
Longer	100	100	100	100	100
No. of companies	55	69	176	225	297

B Pearson[119] in an article 'How to Manage Turnarounds', quotes that "Managing a profitable company is one thing, turning round a business which has gone into loss is quite another. The key to success lies not in complicated systems of management control, but in swift executive action, accomplishing a few simple things extremely well."

In turnround of a company, speed is an important necessity which should be accompanied by a proven framework for tackling the problems. Pearson describes in detail the job of turnround executives and the measures which can be initiated without delay. The next step is to understand what is happening in the business, before taking precipitate executive action. He also provides a "Turnround Situation Management Action Programme" which is shown in Figure 2.1 . This gives various stages of the operation with an approximate time horizon. The article concludes that "A turnround situation must be recognised as a unique problem. Thus ready made answers must be rejected as a physician would discard quack medicine. The outcome of a successful turnround is defined as achieving an adequate return on the total funds invested in the business and not simply as the elimination of losses."

M Allsopp[3] in "Tactics for Survival" writes that "Immediate difficulties may be overcome or deferred by short-term tactical manoeuvres while longer-term adjustments take time to produce improvements. The real remedy more often lies in a combination of short and long-term adjustments .. .. Where there is nothing fundamentally wrong with a company,tactical re-arrangements are appropriate." They involve:

1. Changes in the composition of the board
2. Re-organisation of the company while retaining its existing form
3. The implementation of tighter systems of planning and control
4. Changing the positions held by executives in order to increase their experience and bring fresh minds to key positions in the company.

EXHIBIT 2.1 TURNROUND SITUATION MANAGEMENT ACTION PROGRAMME

First Month

Implement immediate action programmes

Start asking key questions

Investigate sales and marketing

Produce updated financial forecast for the rest of the current year

Second Month

Investigate administration, manufacturing, R & D

Approve objective commitments and action programmes

Programmes for the rest of the current financial year

Third Month

Implement organisational and key management personnel changes

Prepare and implement headcount reduction programmes

Prior to New Financial Year

Approve annual budget, supporting action programmes and business development milestones to be achieved

After Three Months

Decide reposturing needed in terms of:

A planned withdrawal from certain market segments

Diversification into new markets by organic growth

Joint venture and/or acquisition

The possible divestment of the business by selling it as a going concern

5. Revamping personnel policies and systems of rewards.
6. The introduction of improved or supplementary prodúcts
7. The abandonment of prodúcts of declining profitability in order to release capacity for more profitable activities.
8. The creation of new distribution network
9. The re-organisation and revitalisation of sales function

Allsopp explains the items in detail and gives more suggestions.

The failure of companies seem to follow different paths (9) and some authors have attempted to illustrate them based on their own judgement. One of them which is called the cycle of corporate decline is shown in Figure.2.2 is given by Directors (April, 1978).

As can be seen from the chart, the board of directors is the main source of inefficiency which is followed by a weak management. This poor management team makes mistakes and wrong decisions and brings the company to a poor financial position. Other weaknesses cause cumulative difficulties which put the company in one of the following alternatives:

Nationalisation

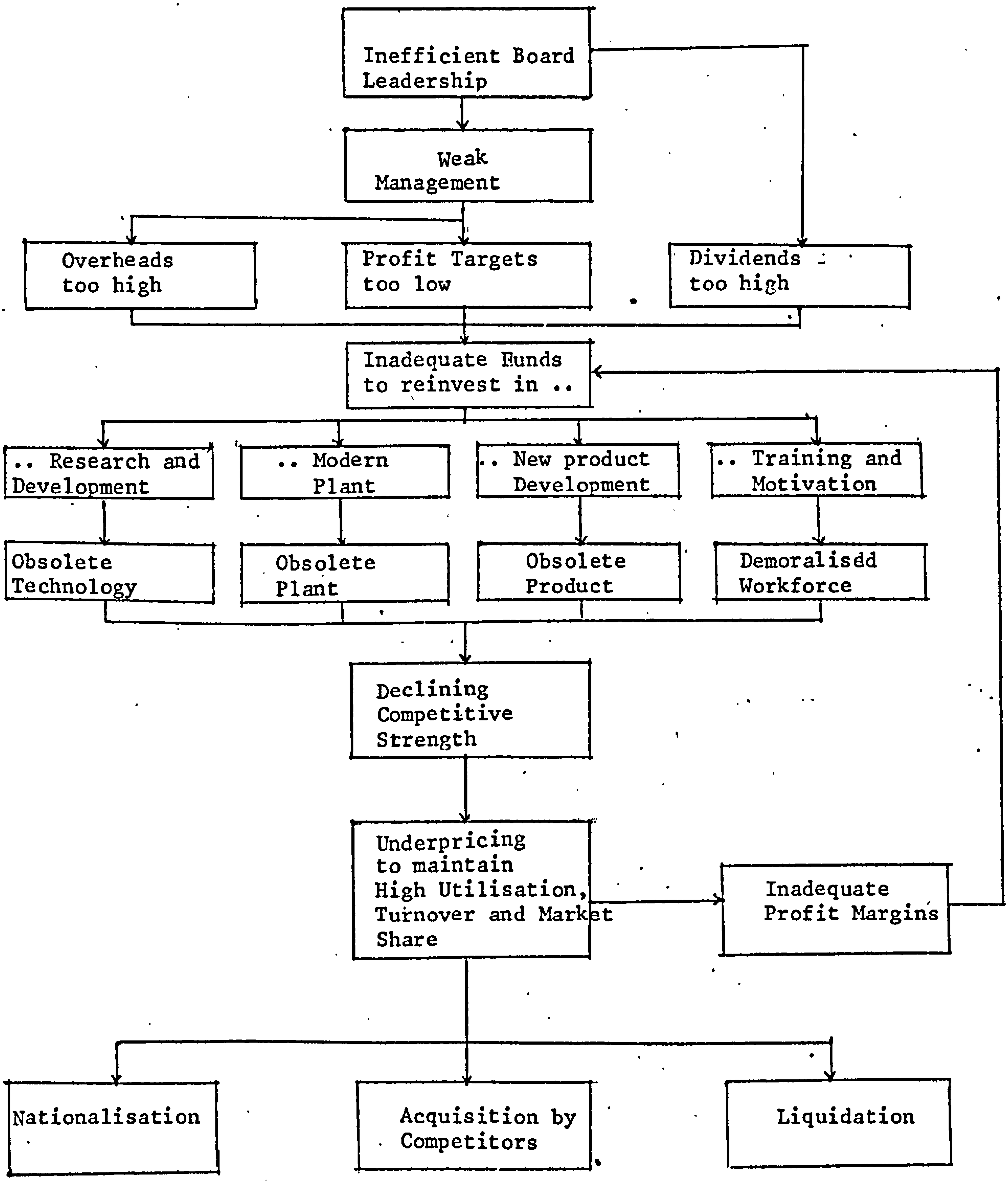
Acquisition by competitors

Liquidation

The review of previous studies shows that many of them are in stark disagreement with each other, for while one writer asserts that one element ia a prime cause of failure, another will explicitly deny this and assert something quite different. The divergence of views is so marked which can be explained by different types of companies studied.

It is common to explain company failures in terms of a list of causes which has been repeated so often as to become almost classical in content. Usually several items from this list of handicaps to the successful operation

EXHIBIT 2.2 THE CYCLE OF CORPORATE DECLINE



of a business are found in connection with a given failure, and hence these factors are said to cause company failure. Common in the literature are such statements as "The failure was the result of ...... (one of the items in the list),", implying that the existence of these conditions causes failures. It is extremely difficult to avoid doing this sort of thing; it seems almost natural to expect that one event causes the other when their occurrence is simultaneous.

It is, indeed, quite possible that a causal relationship does exist between the classical failure reasons and subsequent failures. It is equally possible, however, that the presence of these conditions is not pre-evidence that a given firm is doomed to failure. It is perfectly possible that the so-called causes of business failure are experienced at one time or another by virtually all companies. If this were the case, explanation must be sought elsewhere. Since this raises the possibility that the cause of failure is not the traditional reasons, but rather these reasons superimposed upon some other underlying basic weakness.

It appears that many studies do not concur on any basis as to the underlying basic weakness and determining causes of failure. One of the weaknesses of many studies, the author believes, is that they are trying to find examples to illustrate their pre-reached condlusions based on experience instead of the other way around: e.g. Ross and Kami, Hardie, Cork, Allsopp, Towlson, Cohen, ... Another point is the confusion between causes and symptoms in almost all the cases. For instance, financial items such as working capital is often offered as the cause of failure, but lack of working capital is itself the evidence of more fundamental weakness and a sign of an underlying cause. It may be due to inadequate investment by the owners, deficit operation, overexpansion of current or fixed assets on borrowed funds, excessive dividend payments, poor collections, losses on inventories, or some other factors which may cause the corporation to lack the cash necessary to meet maturing current debt.

It seems that 'bad management' or in a few cases 'mismanagement' is a factor that all the authors agree, causes failure more than any other factor. One cannot disagree with the cause, but the problem is that they fail to introduce the elements or items of bad or mismanagement, generalisation cannot provide a constructive conclusion. Some authors have put figures on this and have tried to break down in a few items, e.g. Brough, Dun and Bradstreet, give the number and percentage of company failure in UK and USA respectively, which is still open to some criticisms. In both cases, one can observe an item such as working capital that, as earlier mentioned, is a symptom rather than a cause, also in Brough's companies, the type of companies, the type of industry or the size is questionable, because the factors of failure in construction industry do not have the same influence on manufacturing companies or if one considers the age and size 'Bad management' in small and young businesses do not construct the similar items and impacts as large organisations. Lack of classification of companies based on some criteria such as type of industry, age, size, etc. is an important weakness of previous studies, e.g. Hartigan, Cohen, Argenti, Hardie, Ross and Kamai, Allsopp, Cork, etc.

The conclusions cannot be taken specifically in identification of causes or symptoms of particular type or group of companies, although they provide some useful points.

On the basis of the studies described, it would appear that no one gives any procedure or method of how to identify or analyse the failure which must be the basis before carrying out the study. They also fail to divide the symptoms to even a general form which consists of financial symptoms and non-financial symptoms. Finally, most of these researches lack empirical data in a specific area.

In spite of the weaknesses and sometimes conflicts between different conclusions the fact remains that all the previous works have been, and the author believes, will be of particular importance to those interested in doing research in this field.

2.4 Conclusions

The dynamic situation of business and inter-relationship between technical, economical, social, political and in general external and internal aspects of the firm calls for the renewal of research and study concerning the failure characteristics and behaviour of companies for different industries and various sizes over time.

There is a need for modification, re-structuring, new developments and exploration in all areas in this field. Having reviewed the existing literature, the present study was designed.

From the review of the literature the author concludes that mismanagement at board level is a significant factor in failure of companies ;this needs more investigation. It is also concluded that the study of age structure of failed companies could provide some indication with regard to the pattern of failures.

DEVELOPMENT OF DATA BANK

AND

A STUDY OF AGE STRUCTURE OF FAILED COMPANIES

3.1 Introduction

Over 200 years ago, Samuel Johnson observed that, "Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it". And back then, he was right.

Since then, however, the amount of knowledge in the world has mushroomed in an information explosion whose tremors we constantly feel. We have been forced to rely less on knowing a subject ourselves, and more on knowing where we can get our hands on relevant information. But we are finding that simply knowing where information is, is not enough. Most of us have to get our hands on the right information much more easily and quickly than we can now.

This chapter is concerned with the search for the right company failure information, to collect, computerise, classify and finally analyse them in order to provide a source of data for those who need the right information more easily and quickly than before and to present the results for those researchers who can use them in the analysis of their work. It also introduces a methodology which was used in the development of a Data Bank, by the author, consisting of approximately 2000 manufacturing companies which went into liquidation in the period 1970-1977.

It is believed by some authors(69) that "inaccuracies in data may arise both in connection with their acquisition and with their use. In both cases possible errors must be judged in the light of the nature of the data and the form of the informations required". The type of data required for this research is particularly related to the failure characteristics of companies.

Before the actual collection of data was accomplished, a study of relevant factors to this study was carried out and the questions relating to the definition of items used in the Data Bank clarified.

3.2 Objectives

The main objective of this chapter is to describe the changes in the number of companies and development of a Data Bank for manufacturing companies which went into liquidation during 1970-1977 in England and Wales. It is aimed to provide a basic framework for the study of companies in Great Britain, and to throw some light on the importance of business mortality and corporate collapse. This study has been carried out with the possibility in mind of ascertaining whether there have been significant changes in the number of companies during the peridd studied.

It is intended to examine the age structure of manufacturing failed companies with regard to their industry group, type of business and year of failure. The further purpose of this chapter is to describe in detail methodology adopted for the collection of data for the present study. It is the belief of the author that this metholology could be applied to other similar studies. The methodology consists of the following three:

1. Identification and definition of items
2. Identification of source of information
3. Acquisition and processing of data.

Each of these stages are described in detail later in the chapter.

Finally, it is anticipated that the Data Bank will prove of some value to other researchers in the area of business failure.

3.3 Area of Study

The manufacturing industry was chosen for study, because of its importance to national economy and the existence of related studies with which to compare results.

3.3.1 The importance of manufacturing industry to the UK economy

Manufactured and semi-manufactured products make up over 80% of Britain's visible exports and the manufacturing industries account for 27% of Britain's Gross Domestic Products. The number of employees in manufacturing industry (including the unemployed and those absent from work through sickness and other causes, but excluding employers and the self-employed) was 7.3 million in June 1976: 32.5% of the total number of employees. In 1976 fixed capital expenditure in manufacturing industry at current prices totalled £3957 million of which over three-quarters represented investment on plant and machinery.

Analysed by industry group, investment in the engineering, shipbuilding and metal goods industries was £813 million, in the chemical industries £634 million, in metal manufacture £722 million and in the food, drink and tobacco group £513 million[106].

The pattern of organisation and ownership in manufacturing industry ranges from such large-scale organisations as the General Electric Company (198,000 employees) and Imperial Chemical Industries (192,000 employees) to the many thousands of small firms, some with fewer than 25 employees but accounting for about one-fifth of the Gross National Product (GNP).

3.4 Period of Study

It was believed by the author that a period of eight years was a significant period of time during which trends should be identified and to allow tabulation and classification of data for this and further studies. The eight year interval from 1970 to 1977 was selected for the following reasons:

a) This period has seen a large change in the balance of the duties and responsibilities of corporate undertakings; these changes have significantly contributed to causing company financial failure. It is believed that "1970 was a particularly significant year for many of today's failures. The government's impact on the running of businesses in the UK is possibly the most decisive factor affecting the wellbeing of economic activity. Government decisions or the lack of them have had and will continue to have an unprecedented effect on business activity"[111]. Inflation, the profit crisis, increased strength of organised labour, decline of investment, increasing involvement of government, external factors such as oil crises and recession make the period of this study a particularly interesting one.

b) Business and economic cycles: Since the beginning of 1970 there have been approximately two cycles of activity in the economy. These cycles have had their impact on the companies and their finances, liquidity and performances. These cycles are identified with the following events: a squeeze in 1970 and 1971, followed by a recovery in 1973, a further squeeze in 1974, followed by a recovery in 1975 and 1976.

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3.5 Classification Used

The classification used in collection of data is based on the Standard Industrial Classification (SIC). SIC is based on industries and not on occupations or operators.

"The classification is arranged in a list of industry headings with the minimum detail which are therefore called Minimum List Headings (MLS). The headings of related industries are grouped into orders"(141).
For the purpose of this classification the unit taken is the 'establishment'. Usually the principal activities carried out in an establishment fall within a single heading of the classification, e.g. steel making, sugar refining. Frequently, distinct activities characteristic of different industries are carried out at one address, e.g. cotton weaving and making up of household textiles, but normally these are not classified separately and the whole establishment is classified according to the main activity. The standard industrial classification for the manufacturing industries only consist of 119 Minimum List Headings which are distinguished by arabic numerals. These Minimum List Headings have been grouped into 16 orders which are distinguished by alphabetical characters. A summary of orders and Minimum List Headings of manufacturing industry is given in Appendix (A). The alphabetical coding used in the Data Bank correspond to the following groups:

Code	Group of Industry
A	Food, drink and tobacco
C	Chemicals and allied industries
D	Metal manufacture
E	Mechanical engineering
F	Instrument engincering
G	Electrical engineering

Code	Group of Industry
H	Shipbuilding and Marine Engineering
K	Vehicles
L	Metal Goods
M	Textiles
N	Leather, Leather Goods and Fur
P	Clothing and Footwear
R	Bricks, Pottery, Glass and Cement
S	Timber and Furniture
T	Paper, Printing and Publishing
U	Other Manufacturing Industries

3.6 Birth and Death of Companies

In Britain the precise number of registered companies on the registers of Companies House - Department of Trade, as at 31 December 1977 was 705,998, of which 627195 companies were effective and 78803 were in liquidation or course of removal.

Table 3.1 gives statistics of new companies registered, dissolved, struck off, restored to the registers, in liquidation or course of removal and the effective number on the registers at 31 December for each year and the whole period of study (1970 to 1977). The new companies registered showed an increasing trend up to 1974 with a peak level of 67349 companies in 1973 which was more than twice the number of new companies registered in 1970. With the economic conditions of 1974, the number of new companies dropped sharply (Fig. 3.1). The average number of new companies registered in each year during the period of study was 48873. The number of dissolved companies reached its peak level in 1977 with 7835 companies. The total number of dissolved companies during 1970-1977 was 56150. The average number of dissolved companies in each year was 7018.

Struck-off companies, which includes a small number converted to non-company status reached its highest level of 32787 in 1977 and a total number of 183926 companies for the period of study.

The effective number of companies which represents the active businesses at the end of each year is the outcome of the difference between the companies on the registers at 31 December and the companies in liquidation or course of removal e.g. the effective number of companies on the registers at 31 December 1977 was 627195 or 88.84% of all companies on the registers in the same period. The other 11.16% represents the companies in liquidation or course of removal in 1977.

Fig. 3.1 gives the movements of each group during 1970 to 1977.

TABLE 3.1 Great Britain's Summary of Changes in the Number of Companies on the Registers 1970-1977

	1970	1971	1972	1973	1974	1975	1976	1977	1970-77
. COMPANIES:									
On register at 1 Jan.	552799	559494	577228	603935	637648	657859	669930	690897	
New companies registered	30262	39445	54456	67349	42496	45678	56085	55214	390985
Dissolved	6596	6536	7580	7718	6168	6484	7233	7835	56150
Struck off*	17154	15343	20318	26117	16406	27495	28306	32787	183926
Restored to the registers	186	165	149	199	289	372	421	509	2290
On registers at 31. Dec.	559497	577228	6P3935	637648	657859	669930	690897	705998	
In liquidation or removal stage	40840	49588	61357	38143	59480	77687	69214	78803	
Effective No. on registers at 31. Dec.	518657	527640	542578	599505	598379	592243	621683	627195	
Notified liquidations	8782	8412	8215	7240	7885	9795	10640	9974	
Dissolved, struck off and notified	32032	30291	36113	41075	30459	43744	46179	50596	
*Including a small number converted to non-company status									

Source: Companies in 1971 to 1978

CHANGES IN THE NUMBER OF COMPANIES ON THE REGISTERS (1970 - 1977)

Fig. 3.1

The number of public companies on the registers at 31 December 1977 was 16819 of which 1184 companies were in liquidation or course of removal. The number of private companies at the end of 1977 was 689179 of which 77619 companies were in liquidation or course of removal. This indicates that in 1977, private companies represented 97.62% of all companies on the registers and only 2.38% were public companies. Table 3.2 and Fig. 3.2 give a better picture of the private and public companies changes during 1970 to 1977.

Before considering the number of liquidations, it is necessary to note that although the actual number of dissolved and struck off companies are given annually, the reasons why they have disappeared are not known. Dissolved and struck off mean when a company ceases to exist as a legal entity and is removed from the registers of companies. This can be for many reasons, including that the Registrar could not obtain a reply to his letters to the company.

The extent of failure in its broadest sense is not entirely clear, because it is very difficult to distinguish between various categories of failure. Each researcher can interpret the scale and dimension of failure based on the definition accepted or chosen. There are two types of liquidation that involve insolvency; compulsory liquidation which stems from winding up orders by courts following petitions to them, and creditors' voluntary liquidation, in which the company and its creditors come to terms without court proceedings.

Table 3.4 gives the number of liquidations notified in England and Wales during the period of study. This includes all types of liquidations. As can be observed from this table, there is generally only a few (1 to 4) liquidations in a year under the supervision of court. These are creditors' voluntary liquidations in which the coirt has intervened as a result of petition during the liquidation and they are included in the statistics of

TABLE 3.2 Great Britain's Summary of Changes in the Number of Public and Private Companies on the Registers(1970-77)

	1970	1971	1972	1973	1974	1975	1976	1977	1970-77
BLIC COMPANIES:									
On Registers at 31. Dec.	16639	16679	16707	16695	16658	16695	16716	16819	
of which in liquidation, or course of removal	1214	1228	1177	1119	1105	1105	1131	1184	
Effective number on registers at 31 Dec.	15425	15451	15530	15576	15553	15590	15585	15635	
IVATE COMPANIES:									
On Registers at 31 Dec.	542858	560549	587228	620953	641201	653235	674181	689179	
of which in liquidation, or course of removal	39626	48360	60180	37024	58375	76582	68083	77619	
Effective number on Registers at 31 Dec.	503232	512189	527048	583929	582826	576653	606098	581360	

Source: Companies in 1971 to 1978

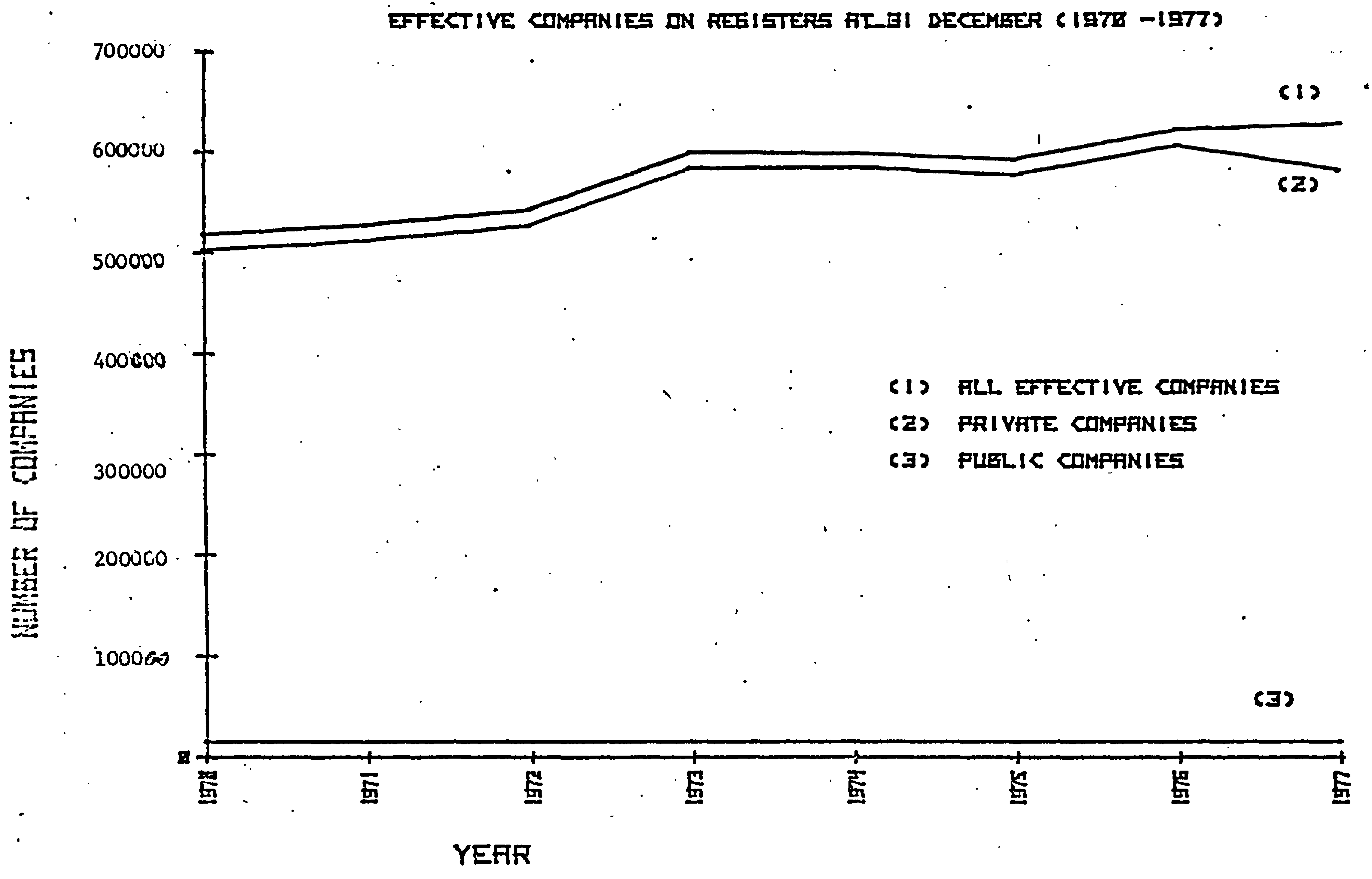

EFFECTIVE COMPANIES ON REGISTERS AT 31 DECEMBER (1970 -1977)
700000
600000
500000
400000
300000
200000
100000
0
NUMBER OF COMPANIES
(1)
(2)
(3)
(1) ALL EFFECTIVE COMPANIES
(2) PRIVATE COMPANIES
(3) PUBLIC COMPANIES
1970
1971
1972
1973
1974
1975
1976
1977
YEAR

Fig. 3.2

TABLE 3.3 Registration of Companies having a share capital analysed by amount of nominal capital (1970-77)

	1970	1971	1972	1973	1974	1975	1976	1977	1970-77
. Companies	28755	37627	51668	64117	39884	42967	53260	52290	370568
ıre Capital:									
Iot exceeding £100	19292	25495	39101	50795	25134	27377	36099	34256	257549
.00-1000	1098	1297	1238	1112	827	753	724	662	7711
.000 and under 5000	5822	7548	7884	8265	8034	7908	8355	8754	62570
;000 " " 10000	1190	1529	1584	1658	2025	2260	2352	2292	14890
.0000 " " 20000	822	1079	1158	1391	2282	2692	3236	3430	16090
?0000 " " 50000	288	422	405	504	740	872	1116	1140	5487
;0000 " " 100000	128	134	143	179	373	521	584	752	2814
.00000" " 200000	64	73	103	135	272	397	574	715	2333
200000" " 300000	17	24	28	30	67	67	87	124	444
300000" " 400000	3	3	4	5	6	11	12	7	51
400000" " 500000	3	-	-	2	7	2	9	6	29
500000" " 750000	13	12	7	15	29	39	54	57	226
750000" " 1000000	2	-	1	4	5	2	3	4	21
1000000 and over	13	11	12	22	83	66	55	91	353

Source: Companies in 1971 to 1978

TEXT CUT OFF IN ORIGINAL

TABLE 3.4 Liquidations Notified in England and Wales (1970-77)

pe of Liquidation	1970	1971	1972	1973	1974	1975	1976	1977	1970-77
1 Types	8268	7956	7743	6872	7466	9315	10112	9481	67213
mpulsory	1269	1166	1150	1080	1395	2287	2511	2425	13283
luntary:	6999	6790	6593	5792	6071	7028	7601	7056	53930
mbers'	4579	4450	4680	4297	3746	3917	4173	3650	33492
reditors'	2420	2340	1913	1495	2325	3111	3428	3406	20438
ubject to the supervision* f the Court	4	1	-	-	-	1	-	-	5

Included in figures for voluntary liquidation

Source: Companies in 1971 to 1978

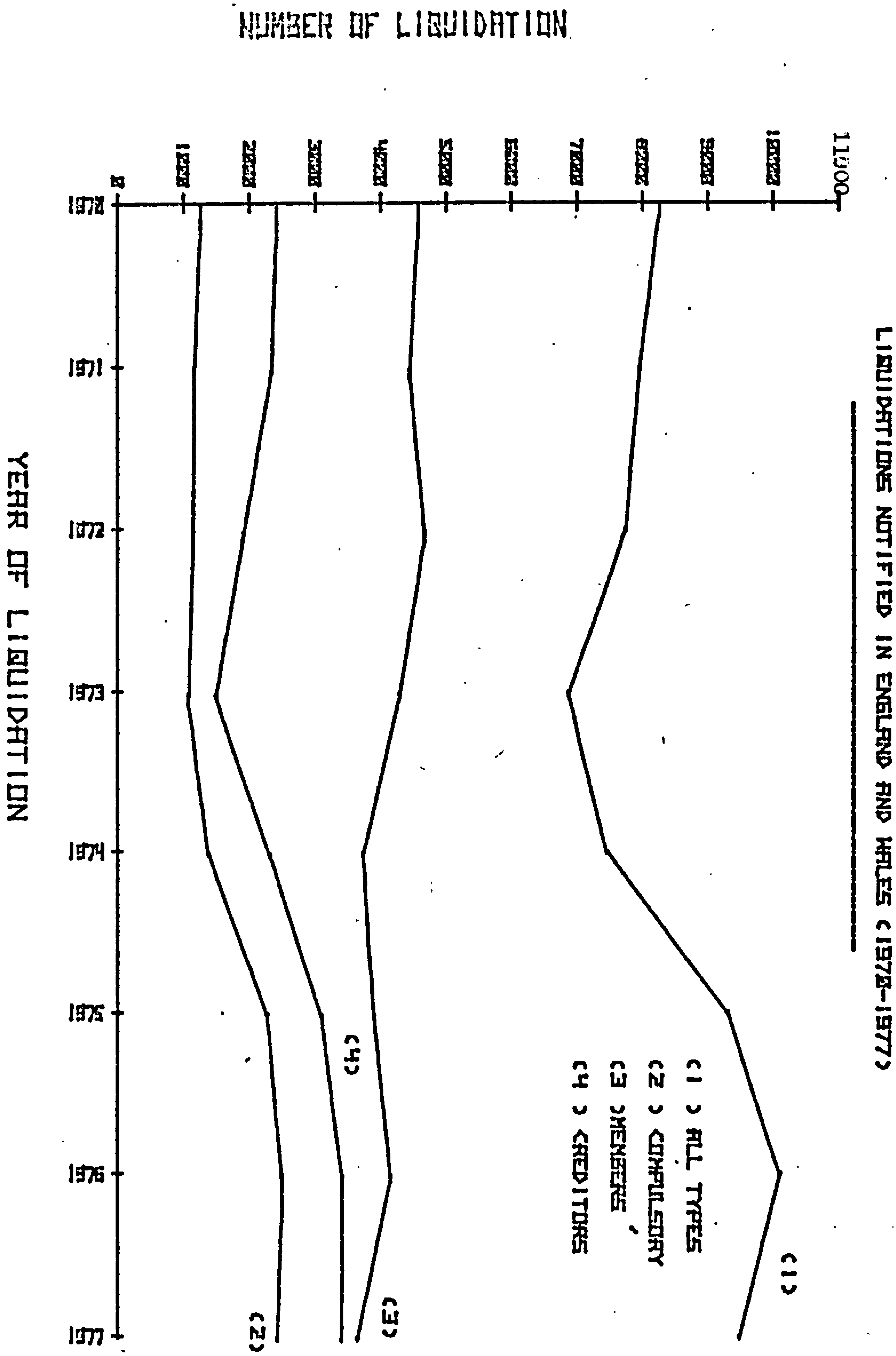

NUMBER OF LIQUIDATION
LIQUIDATIONS NOTIFIED IN ENGLAND AND WALES (1970-1977)
(1) ALL TYPES
(2) COMPULSORY
(3) MEMBERS
(4) CREDITORS
11000
1970
1971
1972
1973
1974
1975
1976
1977
YEAR OF LIQUIDATION

Fig. 3.3

creditors' voluntary liquidation.

The number of liquidations reached its peak level of 10112 companies in 1976 and a total number of 67213 for the period 1970 to 1977. During this period 80.24% of liquidations notified were voluntary and 19.76% compulsory. Considering the voluntary liquidation, 62.1% were Members' Voluntary and 37.2% were Creditors' Voluntary Liquidations. Fig. 3.4 shows that three series: All types, Compulsory and Creditors' voluntary liquidations moved broadly together during this period with a peak level in 1976.

Comparison of the major turning points in longer period has shown some differences in their timing. Compulsory liquidations have tended to change later than creditors' voluntary liquidations and these increases tended to be more gradual and to persist for longer which may be due to compulsory liquidations taking some extra time to work through the courts.

Table 3.5 and Fig. 3.5 illustrate the manufacturing and all industries liquidations during the period of study. On average, 24.52% of all liquidations notified were manufacturing companies.

Table 3.7 gives an industrial analysis of manufacturing companies of total liquidations notified excluding members' voluntary during 1970-1977. The highest number of failures was in Metals and Engineering companies, with 149 in 1976. The lowest number of failures was in the chemical industry, with 13 companies in 1971. Manufacturing industries in this period showed a record level in 1976 with 1319 failed companies. Table 3.8 gives the statistics of notified liquidations for manufacturing companies according to type of liquidation. The average number of compulsory liquidations was 238 companies and 23.05% of total liquidations. The average number of creditors' liquidations in manufacturing industries was 795 with 76.94% of all liquidations.

Fig. 3.8 shows the movements of different liquidations in manufacturing companies.

TABLE 3.5 Liquidations Notified in England and Wales (1970-77)

	All Industries (A)			Manufacturing (B)			%
Year of Liquidation	Compulsory	Creditors'	total	Compulsory	Creditors'	total	B/A
1970	1269	2420	3689	245	709	954	25.86
1971	1166	2340	3506	214	784	998	28.46
1972	1150	1913	3063	212	662	874	28.53
1973	1080	1495	2575	187	535	722	28.04
1974	1395	2325	3270	192	754	946	28.93
1975	2287	3111	5398	356	919	1275	23.62
1976	2511	3428	5939	289	1030	1319	22.21
1977	2425	3406	5831	211	968	1179	20.22
1970-77	13283	20438	33721	1906	6361	8267	24.52

Source: Companies in 1971 to 1978

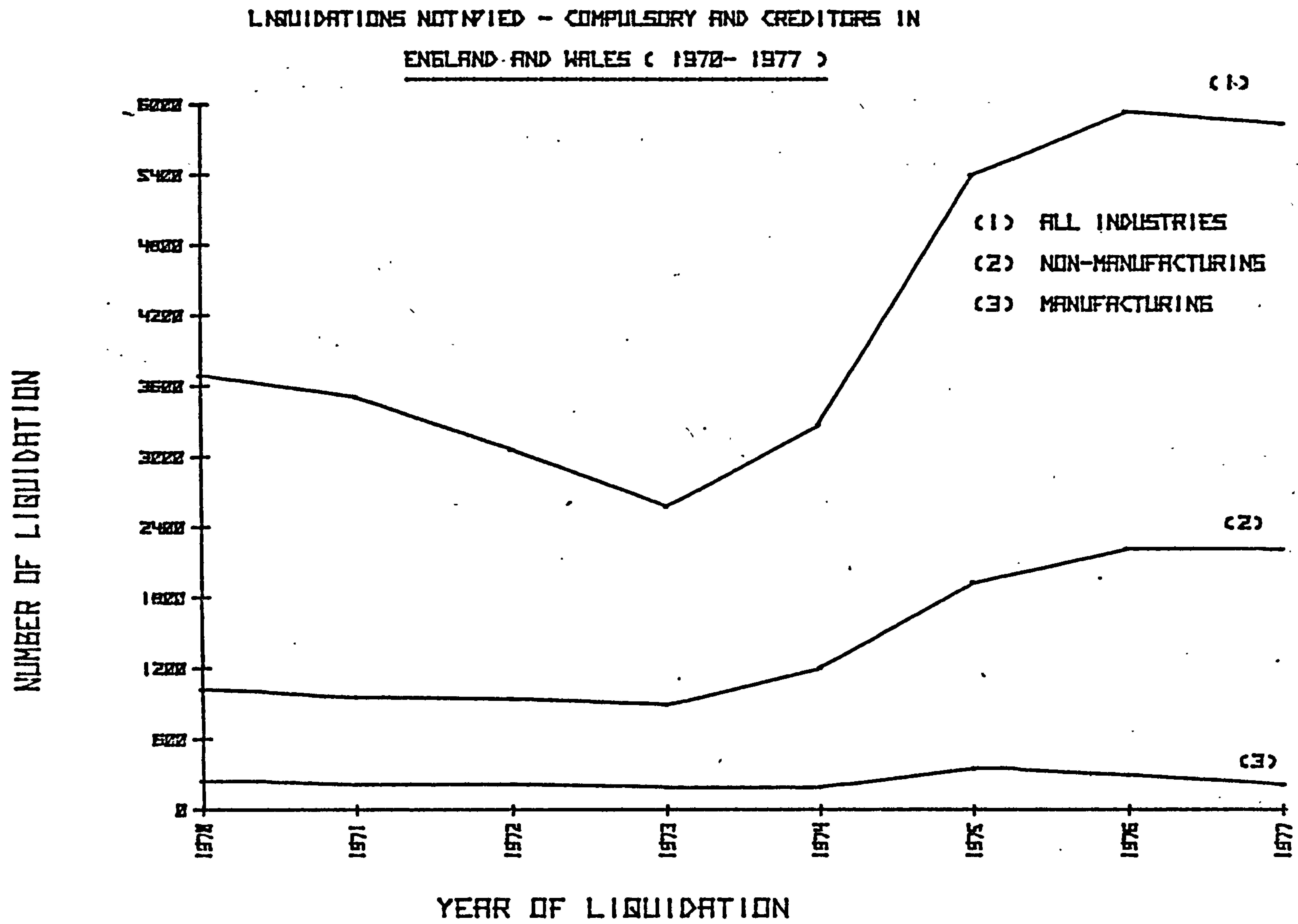

LIQUIDATIONS NOTIFIED - COMPULSORY AND CREDITORS IN
ENGLAND AND WALES (1970- 1977)
(1) ALL INDUSTRIES
(2) NON-MANUFACTURING
(3) MANUFACTURING
(1)
(2)
(3)
NUMBER OF LIQUIDATION
6000
5400
4800
4200
3600
3000
2400
1800
1200
600
0
1970
1971
1972
1973
1974
1975
1976
1977
YEAR OF LIQUIDATION

Fig. 3.5

TABLE 3.7 Total Liquidations Notified (excluding Members') - Manufacturing Industry

	1970	1971	1972	1973	1974	1975	1976	1977	1970-77
Total Manufacturing	954	998	874	722	946	1275	1319	1179	8267
Food, Drink and Tobacco	29	45	40	35	62	62	54	38	365
Chemicals	27	13	36	22	33	53	48	31	263
Metals and Engineering	304	314	302	253	323	400	419	343	2659
Textiles and Clothing	190	218	147	124	171	230	257	239	1576
Timber, Furniture, etc.	110	102	80	61	124	114	121	128	840
Paper, Printing & Publishing	130	125	102	116	124	207	163	136	1103
Other Manufacturing	164	181	167	111	109	209	257	264	1462

Source: Companies in 1971 to 1978

TABLE 3.8 Liquidations Notified - Manufacturing Industries in England & Wales (1970-77)

Year of Liquidation	Compulsory Liquidation	Creditors' Voluntary Liquidation	Total
1970	245	709	954
1971	214	784	998
1972	212	662	874
1973	187	535	722
1974	192	754	946
1975	356	919	1275
1976	289	1030	1319
1977	211	968	1179
1970-77	1906	6361	8267

Source: Companies in 1971 to 1978

LIQUIDATIONS NOTIFIED - MANUFACTURING COMPANIES

IN ENGLAND AND WALES (1970 - 1977)

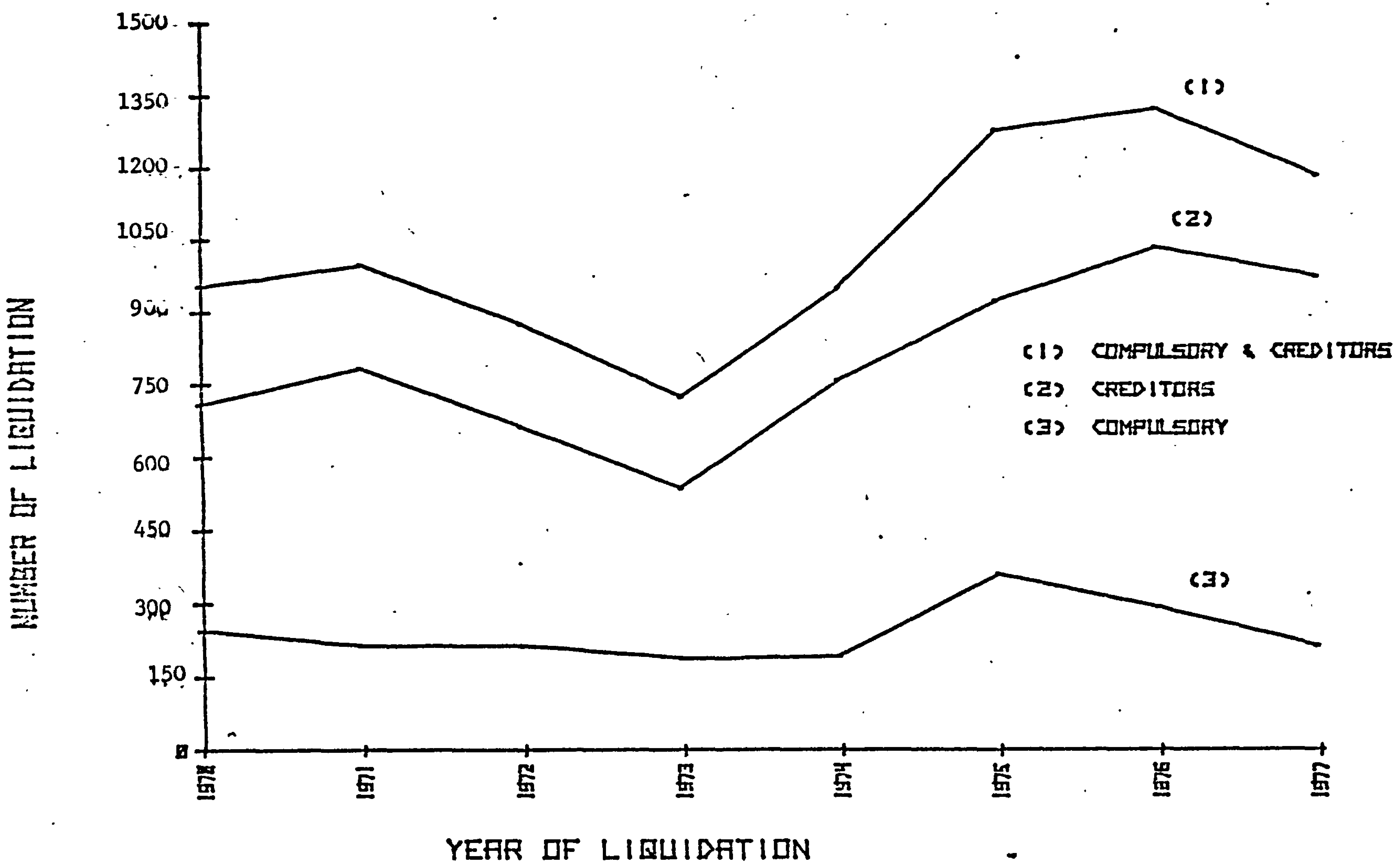


Fig. 3.8

TABLE 3.9 Primary Sample of Company Failure Data

Year of Failure (Liquidation)	Voluntary Liquidation			Compulsory Liquidation	All Liquidations
	Members' and Creditors'	Creditors'	All		
1970	202	179	381	61	442
1971	192	192	384	84	468
1972	187	142	329	70	399
1973	160	154	314	82	396
1974	171	143	314	35	349
1975	268	212	480	71	551
1976	337	253	590	73	663
1977	308	213	521	72	593
1970-77	1825	1488	3313	548	3861

Source: London Gazette 1970 to 1977

The level of business confidence may be gleaned from the rate of new companies registered, but one of the interesting indicators is the formation of new companies in the category of not exceeding £100 share capital as Table 3.3 gives the statistics of newly registered companies having a share capital and analysed by the amount of nominal capital.

The number of companies in the category of not exceeding £100 increased from 1970 and reached its highest level in 1973 with 50795 companies which was 2.63 times the number of new companies registered in 1970 and in the same category.

1974 showed a sharp fall which was a 51% decrease to the 1973 level. This is directly associated with economic conditions and cycles of activity in the economy.

3.7 Identification and Definition of Data

It was stated earlier in this chapter that inaccuracies in data might arise both in connection with their acquisition and their use. In both cases possible errors must be judged in the light of the nature of the data and the form of information required. To do this, it was necessary to identify the area of analysis to be undertaken and the items of data required for this analysis. A review of previous studies showed that although age of companies is one of the most significant variables in business failure prediction models, there is no comprehensive study of age structure of failed UK companies that the author was able to identify. It was decided to apply a reliability methodology to the analysis of company failure data. Having identified the area of study, it was then necessary to identify and define the items required for this study. The following items were considered as the main elements of the Data Bank:

1. Name of the company; 2. Registration Number or Company Number; 3. Incorporation date; 4. Failure data; 5. Age of company; 6. Nominal capital; 7. Industry group.

8. Type of business
9. Type of failure
10. Assets
11. Liabilities
12. Paid-up capital

Definitions

3.7.1 Registration Number

Each company has its own registration number which is also called the company number. This number is necessary for any inspection or reference to the file of the company.

3.7.2 Incorporation Date

The certificate of incorporation is conclusive evidence that the requirements of the Act regarding registration and other relevant matters have been complied with. From the date of incorporation mentioned in the certificate, the corporation can exercise all the functions of an incorporated company. The position is different for the public companies. They cannot commence business until the requirements of section 109 have been complied with. In this study the incorporation date is taken as the formation or established date.

3.7.3 Failure Date

Failure date in development of Data Bank is the date of commencement of liquidation in creditors' voluntary liquidation and winding up order in compulsory liquidation by the court. In this study failure means that the types of company liquidations that involve insolvency, compulsory and creditors' voluntary liquidations. To understand the process and types of liquidations and their differences, one has to define them clearly. This is done under the heading of types of winding-up or liquidation.

3.7.4 Types of Liquidation or winding-up

Winding up a company may be carried out voluntarily, or it may be done by the court or subject to its supervision.

Voluntary liquidation: A voluntary liquidation is either a members' winding-up or a creditors' winding-up.

3.7.4.1 Members' winding-up

This arises where the directors, or the majority of them, make at a directors' meeting a statutory declaration that having made a full enquiry into company affairs, they are of the opinion that the company can pay its debts in full within such period not exceeding twelve months from the commencement of the winding up as may be specified in the declaration. This declaration of solvency must be made at the latest on the day immediately preceding that on which the resolution for voluntary liquidation is passed. The declaration will be ineffective unless:

a) It is made within the five weeks immediately preceding the date of the passing of the resolution.

b) It includes a statement of the company's assets and liabilities as at the latest practicable date before the making of the declaration.

3.7.4.2 Creditors' winding-up

If the directors cannot make the declaration of solvency the liquidation will be a creditors' winding up. A meeting of the creditors is summoned for the day on which will be held the meeting at which the resolution for voluntary liquidation is to be proposed. Notice of meeting must be advertised in the London Gazette and in two local newspapers. Under a presiding director a full statement of the company affairs must be placed before the creditors. When a liquidation is appointed the directors' powers will cease except in a members' voluntary liquidation. The directors remain officers of the company. The company will of course

FIG. 3.9 PROCESS OF VOLUNTARY LIQUIDATION

FIG. 3.10 PROCESS OF COMPULSORY WINDING UP

cease to carry on business except for the purpose of winding up, but its legal status and powers remain until dissolution even if the articles state otherwise.

When the company affairs are fully wound up the liquidator prepares an account showing how it has been conducted and how the company property has been disposed of. He will call a meeting to present the accounts and within one week after the meeting the liquidator must send a copy of the account to the Registrar of Companies. After three months have expired from registration of the return to the Registrar the company is deemed to be dissolved. The liquidator or any other interested person may yet apply to the court to defer the dissolution date for such time as the court thinks fit.

3.7.4.3 Winding up by the court

A company may be wound up by the court if it resolves by special resolution that it shall be so wound up. The other circumstances in which this procedure applies are:

a) where the number of members is reduced below seven (two in a private company.

b) where the company is unable to pay its debts.

c) where the company does not commence business within a year of incorporation, or suspends business for a whole year.

d) where default is made in delivering the statutory report to the Registrar of companies or in holding the statutory meeting.

e) where the court is of the opinion that it is just and equitable that the company should be wound up.

The official receiver is by virtue of his office the provisional liquidator and will remain so until he or another is appointed liquidator. When the affairs of the company have been completely wound up by the court, on the liquidator's application, makes an order for dissolution as from the date of the order. Within two weeks the liquidator will send the Registrar a copy of the order.

3.7.4.4 Winding up under supervision of court

When a company resolves to wind up voluntarily the court may order that the winding up shall be subject to its supervision. The court has power to order the appointment of an additional liquidator,

3.7.4.5 Other legal processes which may result in the failure of business

There are other legal processes which do not go in the insolvency statistics but which may result in a business ceasing to operate. These processes are initiated only by individual creditors, after judgement has been given in their favour and are generally carried out without regard for the claims of other creditors. The most popular of these processes is the levy of execution against the debtors' goods. The process involves the seizure and, if they are not redeemed, sale of the goods. Since 'goods' for this purpose may include machinery the levy of execution may often cause a small business to fail.

3.7.5 Age

From previous studies in the field of corporate collapse and business failure, it would appear that the age variable, as Altman points out, a proxy for age, should be a prime measure to utilise in predictive models and identification of causes and symptoms of failure and finally in prevention or rescue operations. Age in this study is based on the difference between exact date of incorporation and failure date expressed in units of 'months'.

3.7.6 Nominal Capital

If the limited company has a share capital the Memorandum must state the amount of share capital and its division into shares of fixed amount. This nominal or authorised capital is the capital which the company is authorised to raise by the issue of shares. Actual capital depends upon the number of shares that are issued.

3.7.7 Industry order and types of business

These two have already been described in detail in the section of "The classification Used", 3.5. Industry orders are distinguished by alphabetical order and types of business are distinguished by numerals.

3.7.8 Paid up Capital, Assets and Liabilities

These items were drawn from the liquidators' statements at the commencement of liquidation. After the first step of defining the items of data required for the Data Bank, it was important to collect them from the right sources.

3.8 Sources of Information

The data sources for this research can be divided into primary and secondary sources.

3.8.1 Primary sources

The primary sources of data are:

a) London Gazette (1970-1977)

b) Company files

c) Inspector Reports (Department of Trade)

d) Published reports (media)

e) Dissolved companies list

f) Registered Companies list

g) Liquidators and Official Receivers

3.8.2 Secondary sources

a) Defunct companies

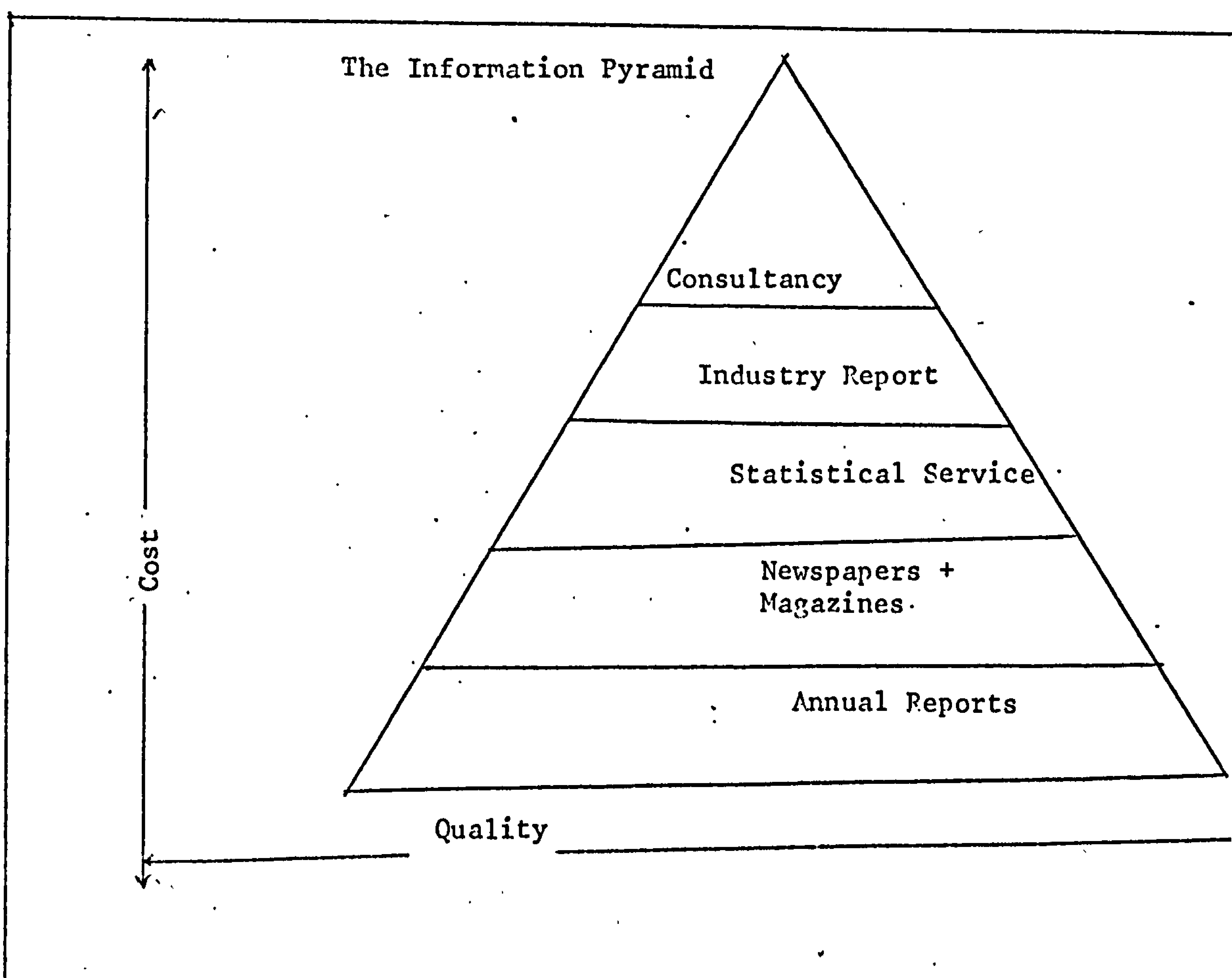
b) Extel statistical services

c) Time 1000

d) Press and media

e) Previous studies .

There are many other sources of informations in UK whose importances vary according to the requirements of different research proposals. R. Coghill in an article describes a few sources of data and concludes that there is an inverse correlation between the quality of information supplied and their costs. The following diagram illustrates this.



3.8.3 Procedure used for Tracing UK Company Information

The chart illustrates the most accessible sources of information for UK companies. It should be noted that there are many other sources in the UK which are not shown in this chart, but will be named later in this chapter.

In recent years considerable effort has been made in developing various data banks in order to provide accurate and readily available information for the study and analysis of company performance and structure. These attempts range from those of academic researchers to private firms and organisations. The major UK data banks and sources of information are given below:

1. Extel statistical services
2. Centre for Interfirm Comparisons Ltd
3. Datastream
4. Computer Information Ltd
5. Dun and Bradstreet Ltd
6. Financial Times
7. Times 1000
8. Investor Chronicle
9. Industrial Aids Ltd
10. Intercompany Comparisons Ltd
11. Gower Press
12. Stockholders' Reports
13. Information Research Ltd
14. Jordan Dataquest Ltd
15. McCarthy Information Ltd
16. Tattersalls of Manchester
17. Sewells Profit and Information Unit

FIG. 3.11 FLOW CHART FOR TRACING UK COMPANY INFORMATION

18. O.W. Roskill Information Services Ltd
19. Quoted Companies' Annual Reports
20. Official Reports by Department of Trade
21. Predicasts Inc.
22. UK Kompass Directory
23. Kompass British Exports
24. Stock Exchange Official Year Book
25. Register of Defunct Companies
26. Who's Who
27. Who Owns Whom
28. Files of newscuttings on local companies
29. Specialised Trade Directories
30. Bradford University Data Bank of Manufacturing Industries.

3.9 Acquisition and Processing of Data

The final part of this chapter is devoted to the procedure followed in the development of Data Bank. In addition to identification and definition of data and sources of information, it was realised that there should be a systematic method of development of data to avoid mistakes and errors in acquisition of informations and their use in the future.

The development of Data Bank can be briefly categorised into six separate stages:

Stage 1	Data Collection
Stage 2	Identification of dissolved and undissolved companies
Stage 3	File collection
Stage 4	Examination and analysis of files
Stage 5	Coding and computerising of data
Stage 6	Programming and tabulation

TABLE 3.10 Comparison of Notified Liquidations between Manufacturing Companies & the Survey

	All Manufacturing Companies			Primary Data Collected			%
Year of Liquidation	Compulsory Liquidation	Creditors' Voluntary	Total (A)	Compulsory Liquidation	Creditors' Voluntary	Total (B)	B/A
1970	245	709	954	61	381	442	46.33
1971	214	784	998	84	384	468	46.89
1972	212	662	874	70	329	399	45.65
1973	187	535	722	82	314	396	54.84
1974	192	754	946	35	314	349	36.89
1975	356	919	1275	71	480	551	43.21
1976	289	1030	1319	73	590	663	50.26
1977	211	968	1179	72	521	593	50.29
1970-77	1906	6361	8267	548	3313	3861	46.70

Sources: 1. Companies in 1971 to 1978

2. Data Bank developed in the present study

3.9.1 Data Collection

This stage of the research was based mainly on a detailed investigation and study of approximately 1600 volumes of the London Gazette (from 1-1-1970 to 31-12-1977), page by page, to identify the companies which went into liquidation considering:

a. Type of business (manufacturing industries)

b. Type of failure (creditors' voluntary liquidation, compulsory liquidation and creditors and members')

Lack of any classification in segregating different industries was the main problem in this stage. The only informations obtained were:

Name of the company

Date of failure (appointment of liquidator)

Type of business

Name and address of liquidator

This process was a long time-consuming one which shaped the basis of Data Bank. The companies were classified according to type of failure (liquidation) and year of failure (1970-1977), with a total number of 3861 companies in manufacturing industry. Table 3.9 gives the number of companies according to the above classifications and its comparison with the total liquidations notified in manufacturing industry in the same period (Table 3.10) in England and Wales.

3.9.2 Identification of dissolved and undissolved companies

This stage required an attempt to identify the companies which had not been dissolved up to 1977. To obtain the undissolved companies, it was necessary to go through the list of all registered companies which contains nearly 700,000 names. The number of companies at the end of this stage was 2000. The registration number of each company was added to their previous information in stage one.

3.9.3 File collection

Although there were some problems at this stage of acquisition and processing of data, regarding the volume of data required, this was resolved with the co-operation of the officials at Companies House and the Department of Trade.

Having completed the special forms for each company, the files for 2000 companies were acquired and prepared for the next stage of analysis. The cost of acquisition of the data was £100 (5p per copy of records).

3.9.4 Analysis of files

Investigation and examination of the company files had to be executed manually, each file being subjected to individual study. The information required for the later analysis had to be obtained from a number of different documents as Incorporation form, Articles of Association, Memorandum, Appointment of Liquidator's form, Winding-up order by court, Liquidator and Official Receiver's statements and in some cases the financial statements and records. This process was carried out for each of the individual 2000 companies studied and the final number of companies which contained all the items of required information as to the previous definition was 1787. These are re-organised in different categories of businesses and industry groups (Table 3.11).

It was found that the process of liquidation varied according to type of business, size and age of companies. It ranged from three months to years. The causes of delay are given in Liquidator's Statements.

3.9.4.1 The causes of termination and delay of winding up

1. Winding up of associated companies
2. Agreement of claims
3. Receiver in possession

TABLE 3.11 Percentage Distribution of Manufacturing Failed Companies according to Different Groups of Standard Industrial Classification

Type of business / Type of liqu.	A	C	D	E	F	G	H	K	L
Compulsory	14	9	7	82	4	26	5	7	32
Creditors' Voluntary	33	39	28	196	14	88	39	35	118
All	47	48	35	278	18	114	44	42	150
Compulsory %	29.78	18.75	20	29.5	22.22	22.81	11.36	16.67	21.33
Creditors %	70.22	81.25	80	70.5	77.78	77.19	88.64	83.33	78.67

Source: Data Bank

Type of business / Type of liquidation	M	N	P	R	S	T	U	All
Compulsory	11	5	32	13	47	49	13	356
Creditors' Voluntary	77	30	245	42	192	190	65	1432
All	88	35	277	55	239	239	78	1788
Compulsory %	12.5	14.29	11.55	23.64	19.67	20.5	16.67	19.91
Creditors' %	87.5	85.71	88.45	76.36	80.33	79.5	83.33	80.09

4. Agreement of taxation liabilities
5. Collection of book debts
6. Setting of liabilities and claims
7. Inland Revenue position
8. Realisation of bad debts
9. Realisation of stock
10. Payment of dividends
11. Consideration of legal matters
12. Collection of retention
13. Receivership not yet completed collection of outstanding debt
14. Delay in the completion of winding up of the company's holding company and various fellow subsidiaries
15. Link with other companies in compulsory liquidation
16. Delays on part of prospective purchaser
17. Possible action against directors
18. Death of previous liquidator
19. Lack of co-operation from directors
20. Investigation by Department of Trade
21. Legal actions against directors
22. Determining assets and liabilities of company, owing to breakdown of accounting systems between the company and other associated companies.

3.9.5 Coding and Computerising

Having acquired the scattered information for each of the 2000 companies, it was necessary to computerise them in order to simplify the further analysis. This process was carried out by coding some of the items. There were many punching errors in the primary lists which were amended and the final lists were prepared in various orders for each item of data. The order of data in these lists is of the following form:

1. Company's Registration Number
2. Incorporation Date
3. Failure Date
4. Age of Company
5. Nominal Capital
6. Group of industry)- Based on standard Industrial
7. Type of Business)- Classification
8. Type of Failure - 1 for creditor's voluntary liquidation
2 for Compulsory Liquidation
9. Assets
10. Liabilities
11. Deficiencies

3.9.6 Programming and Tabulation (Computer Analysis)

This was the last stage in acquisition and processing which required few computer programs to extract the information in various orders. These informations were later tabulated for further research. Tables of failure data with regard to the age structure of companies were prepared for each individual group of industry and year of failure which are given later in the present chapter. All the classified data have been recorded in the author's file in the computer centre of Bradford University, which may be used for other studies in the field of business failure.

3.10 Interpretation of Results

The relationship of failure rate to the age of companies is given in Tables 3.12 to 3.19. These tables present failure data by age in various groups of industry and different years of failure during the period 1970 to 1977.

The special threat of failure to the young firms is evident in the relative failure rate among various age groups (Tables 3.12 to 3.14). A new firm is usually small one which is, as a class, hit harder by failures than larger firms. "The high mortality rate of young and small business enterprise has long been recognised as one of the costs of a system of free competition."[30]

As can be observed from Table 3.12, 3.7% of all failures occur in the first year, 28.8% in the first three years (Table 3.13), 47.2% of companies disappear by the end of the fifth year (Table 3.14) and approximately two-thirds (67.6%) of manufacturing companies fail in the first ten years of their life (Table 3.15).

The highest rate of failure can be seen between the second (12.4%) and the third (12.7%) years for all companies. This is not the same for each individual group, e.g. groups D (metal manufacture), K (vehicles), and R (bricks, glass, etc) show the highest failure rate in their fifth year of life with 14.3%, 16.7% and 16.4% respectively.

The first five to six years represent the high risk period or as Broom and Longenecker[30] state "the 'maiden voyage' for the new firm can provide the real tests of capital, product and business leadership." The results are also consistent with the previous findings that "the longer a company survives, generally other things being equal, the smaller becomes

TABLE 3.12 Length of Life of Manufacturing Companies Failed between 1970 and 1977

INDUSTRY GROUP	Food, Drink and Tobacco	Chemicals and Allied Industries	Metal Manufacture	Mechanical Engineering	Instrument Engineering	Electrical Engineering	Shipbuilding and Marine Engineering	Vehicles	Metal Goods	Textiles	Leather, Leather Goods and Fur	Clothing	Bricks, Pottery, Glass and Cement	Timber and Furniture	Paper, Printing and Publishing	Other Manufacturing Industries	All Manufacturing Companies
AGE	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1	12.8	6.3	5.7	2.9	-	1.8	2.3	7.1	2.7	2.3	2.9	4.3	-	3.8	3.3	7.7	3.7
2	14.9	8.3	-	13.3	22.2	10.5	13.6	7.1	9.3	6.8	5.7	13.4	14.5	16.7	14.6	7.7	12.4
3	4.3	10.4	2.9	12.6	-	18.4	18.2	11.9	11.3	6.8	17.1	10.8	12.7	13.8	13.4	24.4	12.7
4	6.4	10.4	11.4	10.4	5.6	14.9	13.6	11.9	8.0	9.1	14.3	9.7	14.5	10.0	10.0	11.5	10.5
5	-	8.3	14.3	8.3	5.6	9.6	4.5	16.7	10.7	6.8	11.4	7.9	16.4	5.0	6.3	5.1	7.9
6	6.4	4.2	8.6	9.0	11.1	7.9	4.5	4.7	7.3	3.4	5.7	7.2	3.6	5.4	5.8	6.4	6.6
7	4.3	6.3	5.7	4.0	11.1	7.0	4.5	2.4	6.0	4.5	[illegible]	2.5	9.1	3.3	6.7	6.4	4.7
8	-	4.2	2.9	5.0	-	1.8	2.3	7.1	4.7	1.1	2.9	1.8	3.6	2.5	5.4	2.6	3.4
9	2.1	2.0	2.9	1.4	11.1	3.5	2.3	2.4	2.0	4.5	-	5.4	-	5.4	1.3	-	3.0
10	2.1	2.0	-	2.9	5.5	0.8	4.5	2.4	4.0	4.5	2.9	2.5	-	2.9	2.5	2.6	2.7
Over 10	46.8	37.6	45.7	30.2	27.8	23.7	29.5	26.2	34.0	50.0	37.1	34.3	25.4	31.0	30.5	25.6	32.4

TABLE 3.13 Cumulative Percentage Distribution of Length of Life of Manufacturing Companies Failed between 1970 and 1977

INDUSTRY GROUP	Food, Drink and Tobacco	Chemicals and Allied Industries	Metal Manufacture	Mechanical Engineering	Instrument Engineering	Electrical Engineering	Shipbuilding and Marine Engineering	Vehicles	Metal Goods	Textiles	Leather, Leather Goods and Fur	Clothing	Bricks, Pottery, Glass and Cement	Timber and Furniture	Paper, Printing and Publishing	Other Manufacturing Industries	All Manufacturing Companies
AGE	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1	12.8	6.3	5.7	2.9	-	1.8	2.3	7.1	2.7	2.3	2.9	4.3	-	3.8	3.3	7.7	3.7
2	27.7	14.6	5.7	16.2	22.2	12.3	15.9	14.2	12	9.1	8.6	17.7	14.5	20.5	17.9	15.4	16.1
3	32	25	8.6	28.8	22.2	30.7	34.1	26.1	23.3	15.9	25.7	28.5	27.2	34.3	31.3	39.8	28.8
4	38.3	35.4	20	39.2	27.8	45.6	47.7	38	31.3	25	40	38.2	41.7	44.3	41.3	51.3	39.3
5	38.4	43.7	34.3	47.5	33.4	55.2	52.5	54.7	42	31.8	51.4	46.1	58.1	49.3	47.6	56.4	47.2
6	44.8	47.9	42.9	56.5	44.5	63.1	56.7	59.4	49.3	35.2	57.1	53.3	61.7	54.7	53.4	62.8	53.8
7	49.1	54.2	48.6	60.5	55.6	70.1	61.2	61.8	55.3	39.7	57.1	55.8	71.4	58	60.1	69.2	58.5
8	49.1	58.4	51.5	65.5	55.6	71.9	63.5	68.9	60	40.8	60	57.6	75	60.5	65.5	71.8	61.9
9	51.2	60.4	54.4	66.9	66.7	75.4	65.8	71.3	62	45.3	60	63	75	65.9	66.8	71.8	64.9
10	53.2	62.4	54.4	69.8	72.2	76.2	70.3	73.7	66	49.8	62.9	65.5	75	68.8	69.3	74.4	67.6
Over 10	46.8	37.6	45.6	30.2	27.8	23.8	29.7	26.3	34	50.2	37.1	34.5	25	31.2	30.7	25.6	32.4
No. of Failure	47	48	35	278	18	114	44	42	150	88	35	277	55	239	239	78	1787

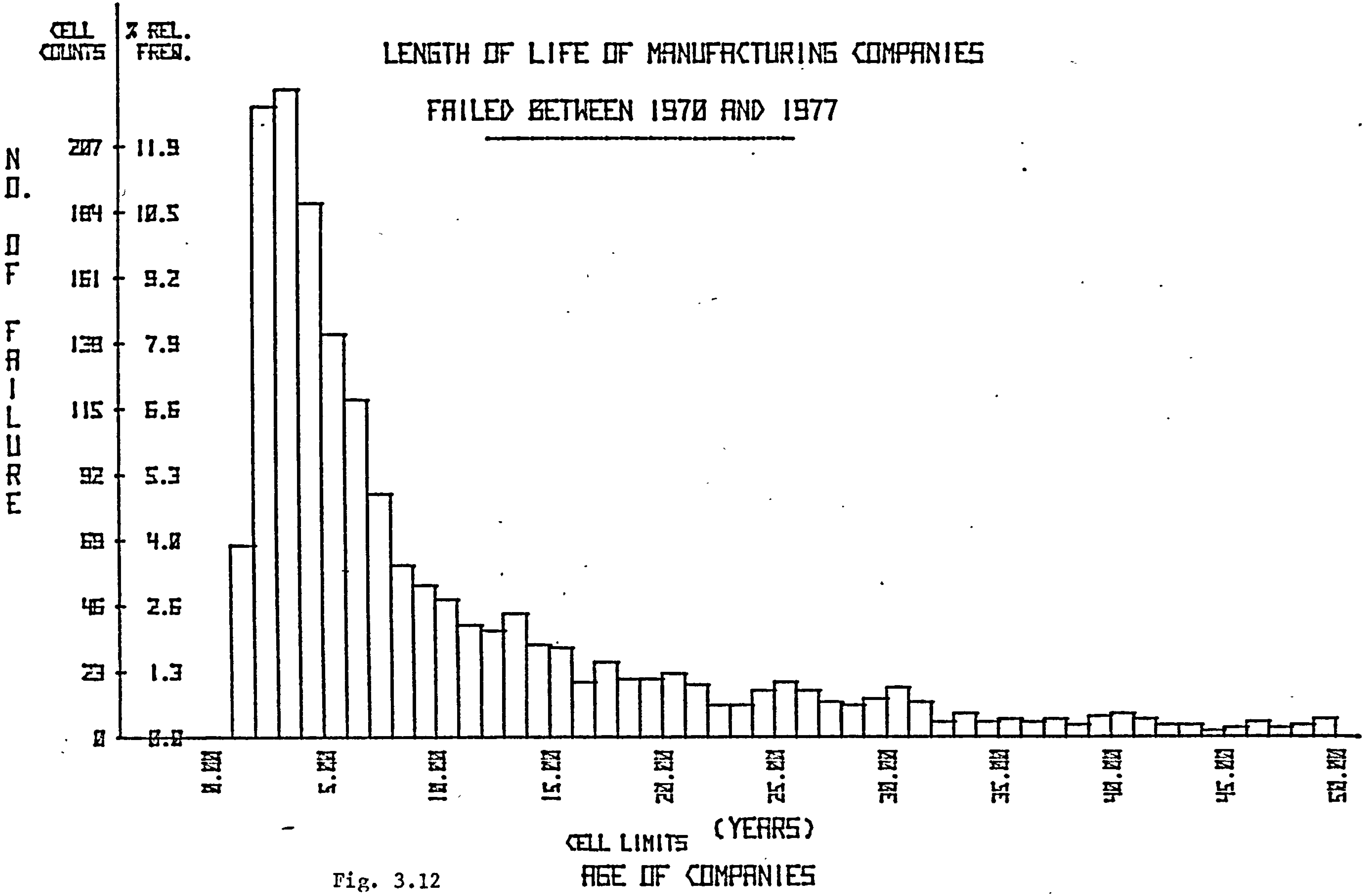

LENGTH OF LIFE OF MANUFACTURING COMPANIES
FAILED BETWEEN 1970 AND 1977
CELL COUNTS
% REL. FREQ.
N O. O F F A I L U R E
207
184
161
138
115
92
69
46
23
0
11.9
10.5
9.2
7.9
6.6
5.3
4.0
2.6
1.3
0.0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
CELL LIMITS (YEARS)
AGE OF COMPANIES

Fig. 3.12

the probability of failure."(101)

Table 3.14, which gives the failure rate of companies in different intervals, indicates that groups U (miscellaneous manufacturing companies) and S (timber and furniture) have the highest early-age or infant mortality rate with 39.7% and 34.3% failure respectively, after the first three years. In the same period groups D (metal manufacture) and M (textiles) with 8.6% and 15.9% respectively show the lowest failure rate. After the first five years group G (electrical engineering) with 55.3% and group M (textiles) with 31.8% failure represent the highest and lowest failure rate. This pattern continues after fifteen, twenty and beyond twenty years. After twenty years, 92.1% of all electrical engineering corporations fail compared with 62.5% failure rate in textiles companies (Table 3.14).

Considering the different groups of manufacturing industry, the textiles business have the best record for longevity and the electrical engineering have the poorest record. More than half (55.3%) of the latter group fail to extend beyond five years and more than three-quarters (76.3%) disappear after the first ten years. Only 7.9% survive beyond twenty years and only 0.9% (nearly one percent) beyond fifty years (Table 3.15).

In the case of textile manufacturing companies, as can be observed from Table 3.14, 50% of failure occur in the first ten years, 62.5% in the first twenty years and 89.9% in fifty years. 9.1% of these companies survive beyond fifty years (Table 3.15) which is ten times greater than the electrical engineering concerns of 0.9%.

Table 3.15 gives the failure of various groups of companies in 10 years intervals. The failurerate sharply decreases from 67.5% for the first interval (0-10 years) to 16.2% for the second one (10-20 years). The failure rate diminishes in other intervals from 16.2% to 8.1%, 3.7% and 2.2%. Only 2.3% of all failed companies had an age of more than fifty years.

TABLE 3.14 Length of Life of Manufacturing Companies Failed between 1970 and 1977 (various intervals)

INDUSTRY GROUP	Food, Drink and Tobacco	Chemicals and Allied Industries	Metal Manufacture	Mechanical Engineering	Instrument Engineering	Electrical Engineering	Shipbuilding and Marine Engineering	Vehicles	Metal Goods	Textiles	Leather, Leather Goods and Fur	Clothing	Bricks, Pottery, Glass and Cement	Timber and Furniture	Paper, Printing and Publishing	Other Manufacturing Industries	All Manufacturing Companies
AGE	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
0-3	31.9	25	8.6	28.8	22.2	30.7	34.1	26.2	23.3	15.9	25.7	28.5	27.3	34.3	31.4	39.7	28.8
0-5	38.3	43.8	34.3	47.5	33.3	55.3	52.3	54.8	42	31.8	51.4	46.2	58.2	49.4	47.7	56.4	47.1
0-10	53.2	62.5	54.3	69.8	72.2	76.3	70.5	73.8	66	50	62.9	65.8	74.5	69	69.5	74.4	67.5
0-15	74.5	75	62.9	81.3	72.2	88.6	81.8	83.3	77.3	56.8	71.4	77.3	81.8	76.1	79.9	80.7	77.7
0-20	83.0	89.6	74.3	86	83.3	92.1	86.4	83.3	84.7	62.5	74.3	83.9	81.8	83.6	85	88.5	83.7
Over 20	17.0	10.4	25.7	14	16.7	7.9	13.6	16.7	15.3	37.5	25.7	16.1	18.2	16.4	15	11.5	16.3

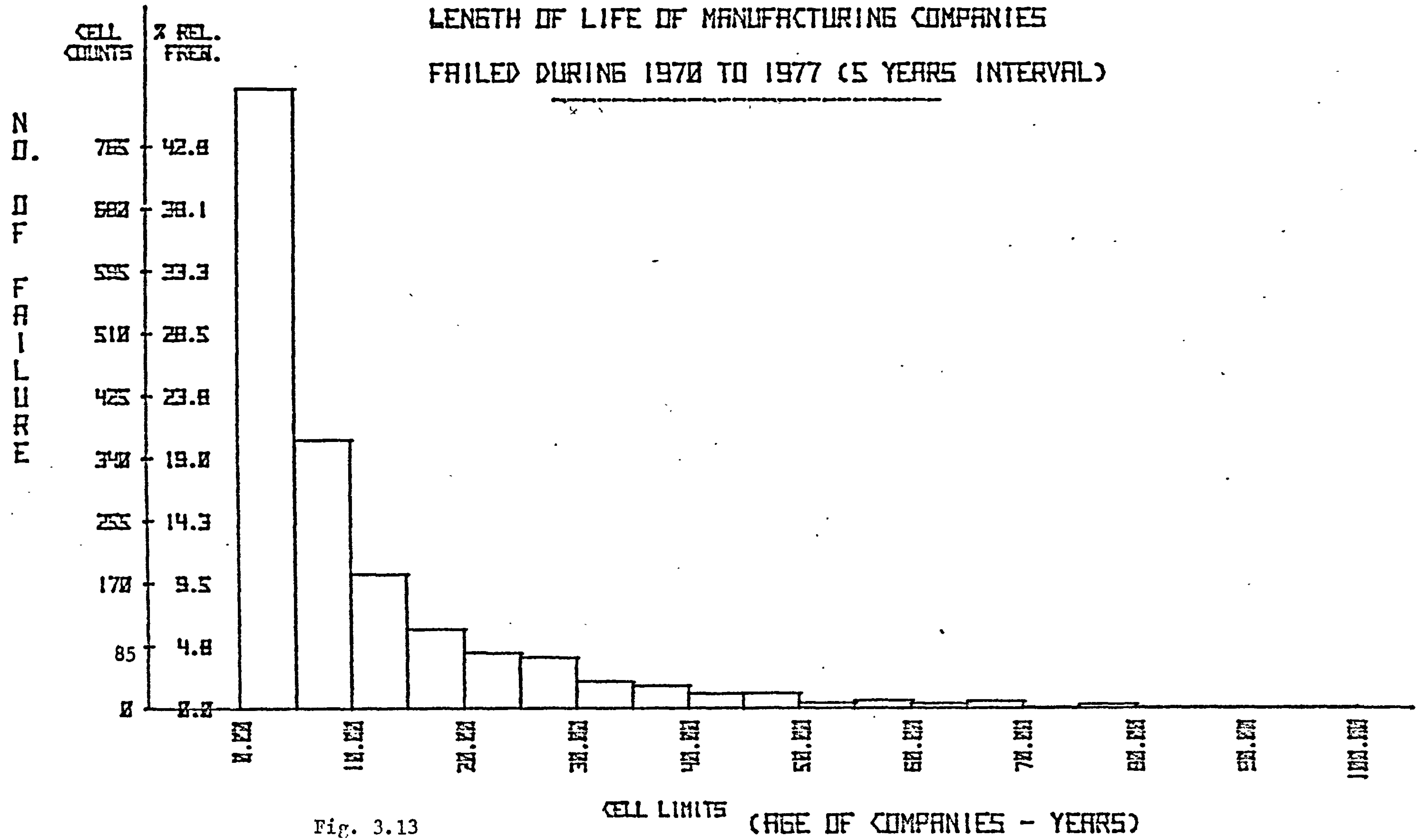

LENGTH OF LIFE OF MANUFACTURING COMPANIES
FAILED DURING 1970 TO 1977 (5 YEARS INTERVAL)
CELL COUNTS
% REL. FREQ.
NO. OF FAILURE
765
680
595
510
425
340
255
170
85
0
42.8
38.1
33.3
28.5
23.8
19.0
14.3
9.5
4.8
0.0
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
100.00
CELL LIMITS
(AGE OF COMPANIES - YEARS)

Fig. 3.13

TABLE 3.15 Length of Life of Manufacturing Companies Failed between 1970 and 1977 (10 year intervals)

INDUSTRY GROUP	Food, Drink and Tobacco	Chemicals and Allied Industries	Metal Manufacture	Mechanical Engineering	Instrument Engineering	Electrical Engineering	Shipbuilding and Marine Engineering	Vehicles	Metal Goods	Textiles	Leather, Leather Goods and Fur	Clothing	Bricks, Pottery, Glass and Cement	Timber and Furniture	Paper, Printing and Publishing	Other Manufacturing Industries	All Manufacturing Companies
AGE	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
0-10	53.2	62.5	54.3	69.8	72.2	76.3	70.5	73.8	66	50	62.9	65.8	74.5	69	69.5	74.4	67.5
10-20	29.8	27.1	20.0	16.2	11.1	15.8	15.9	9.5	18.7	12.5	11.4	18.1	7.3	14.6	15.5	14.1	16.2
20-30	8.5	6.3	17.1	8.3	11.1	3.5	9.1	7.1	7.3	13.6	14.3	8.3	7.3	7.1	6.7	9.0	8.1
30-40	6.4	2.1	8.6	1.4	5.6	1.8	-	4.8	2.6	3.4	2.9	5.1	7.3	6.3	3.3	1.3	3.7
40-50	-	2.1	-	2.2	-	1.8	2.3	2.4	2.0	11.4	5.7	1.8	1.8	2.1	0.8	-	2.2
Over 50	2.1	-	-	2.2	-	0.9	2.3	2.4	3.3	9.1	2.9	1.1	1.8	0.8	4.2	1.3	2.3

LENGTH OF LIFE OF MANUFACTURNNG COMPANNES
FAILED BETWEEN 1970 AND 1977 (10 YEARS INTERVAL)
CELL COUNTS
% REL. FREQ.
NO. OF FAILURE
$$$$
968
847
726
605
484
363
242
121
0
61.0
54.2
47.4
40.6
33.9
27.1
20.3
13.5
6.8
0.0
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
CELL LIMITS
(AGE OF COMPANIES - YEARS)

Fig. 3.14

Table 3.13 gives the cumulative percentage distribution of failed companies for various groups. Tables 3.16 to 3.19 provide the failure data for individual years of failure and the whole period (1970-1977).

It is to be expected that the mortality of business enterprises will vary from year to year with business conditions as is suggested that "the rate of failure fluctuates from year to year because of changes in general economic conditions and other factors and is closely associated with general economic conditions."(30). Although the period of the present study is not long enough to show long-term trends in length of life, the effect of economic conditions of 1973 to 1975 in the UK is quite evident in the relative failure rate among various age intervals. Table 3.17 which portrays the relationship of the cumulative failure rate to the age of businesses in various years, clearly shows the high rate of mortality among concerns in business five years or less, e.g. 55.3%, 50.2% and 51.2% for 1973, 1974 and 1975 respectively, compared with 29.5% in 1972 which was a recovery year.

The percentages of companies failed in these years with the age of more than 20 years are given in Table 3.18. This indicates that only 12.8% and 12.9% of all failed companies in 1973 and 1974 were over 20 years while in 1972 this percentage is 25.7% or nearly two times that of 1973.

Table 3.20 gives the number of failed companies for various groups of companies during the period of study (1970-1977). This Table indicates that group P (clothing industry) has the highest number of failures in a single year with 85 companies failed in 1977. The highest number of failures during the whole period occurred in group E (mechanical engineering) with 278 companies and group P (clothing) with 277 companies. The lowest number of failures was 18 companies in group F (instrument engineering). The year 1976 showed the highest number of failures (475) companies and in

TABLE 3.16 Length of Life of Manufacturing Companies Failed between 1970 and 1977

Year of Failure	1970	1971	1972	1973	1974	1975	1976	1977	1970–1977
Age	%	%	%	%	%	%	%	%	%
1	4.9	5.6	1.9	3.5	3.9	2.9	4.2	3.7	3.7
2	11.5	13.3	7.6	17	10.6	14.7	11.2	12.4	12.4
3	9.8	10	6.7	12.8	17.3	15.3	11.6	12.6	12.7
4	8.2	3.3	9.5	13.5	8.9	9.8	12.6	10.3	10.5
5	9.8	5.6	3.8	8.5	9.5	8.5	7.6	8.2	7.9
6	11.5	11.1	3.8	2.1	8.9	6.2	4.6	8.6	6.6
7	6.6	3.3	11.4	4.3	4.5	3.3	4.2	5.1	4.7
8	3.3	6.7	2.9	4.3	2.8	2.3	4.0	2.8	3.4
9	1.6	5.6	8.6	0.7	3.9	2.3	3.2	1.9	3.0
10	1.6	-	2.9	5.7	1.1	3.9	2.5	2.3	2.7
Over 10	31.1	35.6	41	27.7	28.5	30.9	34.3	32.2	32.4
No. of Failures	61	90	105	141	179	307	475	429	1787

TABLE 3.17 Cumulative Distribution of Length of Life of Manufacturing Companies Failed between 1970 and 1977

Year of Failure	1970	1971	1972	1973	1974	1975	1976	1977	1970–1977
Age	%	%	%	%	%	%	%	%	%
1	4.9	5.6	1.9	3.5	3.9	2.9	4.2	3.7	3.7
2	16.4	18.9	9.5	20.5	14.5	17.6	15.4	16.1	16.1
3	26.2	28.9	16.2	33.3	31.8	32.9	27	28.7	28.6
4	34.4	32.2	25.7	46.8	40.7	42.7	39.6	39.0	39.1
5	44.2	37.8	29.5	55.3	50.2	51.2	47.2	47.2	47
6	55.7	48.9	33.3	57.4	59.1	57.4	51.8	55.8	53.6
7	62.3	52.2	44.7	61.7	63.6	60.7	56	60.9	58.3
8	65.6	58.9	47.6	66	66.4	63	60	63.7	61.7
9	67.2	64.5	56.2	66.7	70.3	65.3	63.2	65.6	64.7
10	68.8	64.5	59.1	72.4	71.4	69.2	65.7	67.9	67.4
Over 10	31.2	35.5	41	27.6	28.6	30.9	34.3	32.1	32.6
No. of Failures	61	90	105	141	179	307	475	429	1787

TABLE 3.18 Length of Life of Mnaufacturing Companies Failed Between 1970 and 1977 (Various intervals)

Year of Failure	1970	1971	1972	1973	1974	1975	1976	1977	1970–1977
Age	%	%	%	%	%	%	%	%	%
0–3	26.2	28.9	16.2	33.3	31.8	32.9	26.9	28.7	28.8
0–5	44.3	37.8	29.5	55.3	50.3	51.1	47.1	47.1	47.2
0–10	68.9	64.4	59	72.3	71.5	69.1	65.7	67.8	67.5
0–15	78.7	77.8	71.4	78	85.4	77.9	75.4	78.3	77.7
0–20	80.3	82.2	74.3	87.2	87.1	85	82.7	84.4	83.7
Over 20	19.7	17.8	25.7	12.8	12.9	15	17.3	15.6	16.3
No. of Failures	61	90	105	141	179	307	475	429	1787

Table 3.19 Length of Life of Manufacturing Companies Failed between 1970 and 1977 (10 year intervals)

Year of Failure	1970	1971	1972	1973	1974	1975	1976	1977	1970-1977
Age	%	%	%	%	%	%	%	%	%
0-10	68.9	64.4	59	72.3	71.5	69.1	65.7	67.8	67.5
0-20	80.3	82.2	74.3	87.2	87.1	85	82.7	84.4	83.7
0-30	91.8	88.9	85.8	93.6	92.7	92.8	90.7	93.2	91.8
0-40	95.1	92.2	94.3	95.7	97.8	95.1	94.7	96.5	95.5
0-50	95.1	95.6	96.2	97.2	99.4	97.4	97.5	98.6	97.6
Over 50	4.9	4.4	3.8	2.8	0.6	2.6	2.5	1.4	2.4
No. of Failures	61	90	105	141	179	307	475	429	1787

TABLE 3.20 Failure Distribution of Manufacturing Companies (1970-1977) According to Type of Industry

INDUSTRY GROUP / Year of Failure	Food, Drink and Tobacco	Chemicals and Allied Industries	Metal Manufacture	Mechanical Engineering	Instrument Engineering	Electrical Engineering	Shipbuilding and Marine Engineering	Vehicles	Metal Goods	Textiles	Leather, Leather Goods and Fur	Clothing	Bricks, Pottery, Glass and Cement	Timber and Furniture	Paper, Printing and Publishing	Other Manufacturing Industries	All Manufacturing Companies
1970	2	-	1	13	2	6	3	1	4	1	-	6	1	7	11	3	61
1971	7	2	-	15	-	7	1	1	8	5	1	8	3	17	12	3	90
1972	5	2	3	20	-	3	1	5	12	4	2	16	5	11	11	5	105
1973	4	3	5	24	1	10	4	5	10	8	2	13	4	12	24	11	141
1974	5	5	3	24	2	14	10	4	10	11	6	24	7	19	31	5	179
1975	8	9	4	57	2	25	8	11	26	13	4	48	8	34	42	8	307
1976	8	18	12	68	3	24	7	9	49	27	9	77	8	63	69	24	475
1977	7	9	7	57	8	25	10	6	31	19	11	85	19	77	39	19	429
1970 - 1977	47	48	35	278	18	114	44	42	150	88	35	277	55	239	239	78	

TABLE 3.21 A Comparison of the Length of Life of Manufacturing Companies

Age (year) / Authors	1	2	3	Total three years	4	5	Total five years	6	7	8	9	10	Total ten years	Over 10	Tot
	%	%	%		%	%		%	%	%	%	%			
Hutchinson	10.0	16.0	14.0	40.0	8.0	7.0	55	8.0	6.0	4.0	2.0	1.0	76.0	24.0	100
USA	2.0	11.9	11.8	25.7	11.9	9.7	47.3	7.4	4.6	4.1	3.2	2.8	69.4	30.6	100
Present Study	3.7	12.4	12.7	28.8	10.5	7.9	47.2	6.6	4.7	3.4	3.0	2.7	67.6	32.4	100

SOURCES: American Economic Review "Study of Business Mortality" Hutchinson & Newcomer, Table XII

Table in "Failure Record Through 1969", Dunn and Bradstreet, New York, p.9

Table 3.12 in present study

the year 1970 the lowest number of failures occurred with only 61 companies.

Table 3.21 shows the age distribution of manufacturing companies in UK and USA. As can be observed, approximately half of the companies fail up to five or six years of their life, and around two-thirds disappear after the first ten years. Less than one-third of manufacturing companies failed were in the age group of over 10 years. The higher percentage of failures for Hutchinson study is due to the size of companies that he studied which were comparatively smaller than the other two. They were the companies in a small town and not a sample of the country.

3.11 Conclusions

28.8% of all manufacturing company failures in England and Wales during the period between 1970 and 1977 occurred in the first three uears, nearly half of the companies failed to survive more than five years. Only one-third of all companies extended their life beyond ten years. Approximately 84% of companies failed in the first twenty years and only 2.3% survived beyond fifty years of age (Tables 3.12 to 3.15).

Textiles industries have the best record for longevity and electrical engineering the poorest.

The impact of economic climate is more evident on young companies than old ones. This can be observed from the relationship between age of companies and various years of failure. (Tables 3.16 to 3.19).

The first five to six years represent the high risk period for the young companies and new businesses. The rate of failure is diminished from the first decade (0 to 10 years) to the fifth one (40 to 50 years). The results are consistent with the views that the longer a company survives, other things being equal, the smaller becomes the probability of failure.

It should also be noted at this stage that the Data Bank with various classified data is available consisting of approximately 2000 companies.

The classification used in this study is based on Standard Industrial Classification and the manufacturing industry was chosen as the area of study because of its importance to national economy.

CHAPTER FOUR

APPLICATION OF RELIABILITY MANAGEMENT METHODOLOGY

TO THE

ANALYSIS OF COMPANY FAILURE

4- APPLICATION OF RELIABILITY MANAGEMENT METHODOLOGY TO THE ANALYSIS OF COMPANY FAILURE.

4.1 Introduction

The purpose of this chapter is to explore the application of reliability methodology to the analysis of company failure data and to draw attention to a new category of failure theory: business failure and mortality.

Although from the review of the previous studies in this field it would appear that the age variable would be a prime measure to utilise in a bankruptcy prediction model, there is no evidence of any investigation regarding the failure pattern, behaviour and structure of companies in UK.

Recognition of business failure pattern is of considerable importance in:

a) identification of causes and symptoms of failure .

A properly identified pattern of failure provides a framework for the analysis of causes and symptoms of failure in different stages of company life cycle and avoids generalisation and confusion made by the previous authors.

b) prediction of company liquidation (failure)

Although the authors of failure prediction models argue that "one of the most outstanding and seemingly irrevocable failure statistics is the high propensity on the part of young firms to fail"[4], and point out that "the chance of a young firm being classified as bankrupt is relatively higher than older firms"[4] there is not any indication of the distinction between 'young' and 'old' firms and their probability of failure and survival at each stage of their life cycle. These can be obtained from the present study based on reliability functions and hazard rate plots.

c) rescue operations

Rescue operations which consist of prevention, turnaround, reorganisation and in some cases liquidation can be possibly carried out more effectively if one can refer to failure characteristics of companies in any particular stage, which is provided in this chapter, to find out the propensity of the company to fail at any point. It can be concluded from the above applications that the reliability analysis of company failure data can develop a methodology and be used as a tool for any study regarding the company and business mortality.

4.2 Business Failure

It is fairly well established that "the longer a company survives, generally other things being equal, the smaller becomes the probability of failure"[101] and "with most types of business the early years are the most difficult. It is then that mortality is highest".[86] Davis[48] in a paper on failure data, broadly analyses three types of failure theory:

(a) The normal theory of failure, in which the failure probability density function is Gaussian.

(b) Human mortality, characterised by rapid increase of the conditional density function after middle-age.

(c) Exponential theory of failure, in which the conditional density function is constant.

In (a) uniformly and in (b) after the very early years of life the conditional density function of failure probability with time is strictly monotonic increasing. In (c) it is constant. Lomax[104] referring to the above paper comments that "the economist immediately thinks of business failures in which it is reasonable to expect the conditional density function strictly to decrease monotonically".

The objective of this chapter is to analyse the compiled manufacturing company failure data in England and Wales during the period 1970 to 1977 to obtain the best pattern of failure and most appropriate distribution which can describe different stages of company life cycle.

4.3 Reliability Management

Reliability management methodology which is the basis of the present chapter is defined by Airing (2) as "A body of concepts, mathematical models and methods directed toward the solution of problems, for predicting, estimating or optimising the probability of survival, mean life, and more generally life distribution of components or systems".

The present-day theory of reliability has been developed during the last two decades by engineers and mathematicians in different countries. Among the first American textbooks were those by Bazovisky (1961) and Lloyd and Lipow (1962), Zelen (1963), Barlow and Proschan (1965). The Russian textbooks on reliability were written by Sahar (1962), Polavko (1964), Berg (1964) and Gnedenko (1965).

The need for and the importance of reliability has been reflected in the constantly increasing emphasis placed on it by research institutions, government and commercial industries. During the past few years, the reliability effort grew to include many diverse activities. This study is one of the first to integrate reliability and business data for the analysis of companies.

4.4 Basic Concepts of Reliability

4.4.1 Definition of reliability

The most commonly accepted definition of reliability is given by Airing Research Corporation[2] as "Reliability is the probability that a system will perform satisfactorily for at least a given period of time when used under stated conditions".

A reliability function is this same probability expressed as a function of the time period. Thus, reliability relates to the frequency with which failures occur. Here "failure" means "unsatisfactory performance", usually representing a judgement of an operator. This does not preclude the possibility of clear-cut failure, such as complete inoperability, in which case judgement does not enter at all. Since reliability is concerned with failure, it can only be measured by observing failure.

Barlow and Proschan(14) define the reliability as "the probability of a system performing its purpose adequately for the period of time intended under the operating conditions encountered".

The period of time intended is (0,t). Mathematically, the reliability function is expressed as:

$$R(t) = P(T>t) = \int_t^\infty f(t)dt \qquad (4.1)$$

where

$f(t)$ is the probability density function

Also,

$$R(t) = 1-F(t) = 1 - \int_0^t f(t)dt \qquad (4.2)$$

where

$F(t)$ is the cumulative failure distribution function

4.4.2 Failure rate

The probability of failure in a given time interval t_1 to t_2 can be expressed by the reliability function

$$\int_{t_1}^\infty f(t)dt - \int_{t_2}^\infty f(t)dt = R(t_1) - R(t_2) \qquad (4.3)$$

Failure rate $Q(t)$ which is the rate at which failure occurs in the interval t_1 to t_2 is defined as the ratio of the probability that failure occurs in the interval, given that it has not occurred prior to t_1; the start of the interval, divided by the interval length, thus:

$$Q(t) = \frac{R(t_1) - R(t_2)}{(t_1-t_2).R(t_1)} \qquad (4.4)$$

Alternatively:

$$Q(t) = \frac{R(t) - R(t+h)}{h.R(t)} \qquad (4.5)$$

where $t_1 = t$ and

$t_2 = t+h$

4.4.3 Hazard rate

The hazard rate or instantaneous failure rate, denoted by h(t), is defined as the limit of the failure rate as the interval length approaches zero. Then the hazard rate is:

$$h(t) = \lim_{h \to 0} \frac{R(t)-R(t+h)}{hR(t)} = -\frac{1}{R(t)} \frac{dR(t)}{dt}$$

$$= \frac{f(t)}{R(t)} \qquad (4.6)$$

This can also be written as

$$h(t) = \frac{-d\ln R(t)}{dt} \qquad (4.7)$$

The hazard function is useful in describing the effect of failures on the population as a function of time. Hazard rate which is sometimes called the force of mortality is the conditional probability of failure of a device or system during the next interval of time (t+h), given that it has survived till time t.

Referring to Fig. 4.1, the hazard rate can be written as:

$$h(t) = \frac{f(t)}{R(t)} \tag{4.8}$$

where

$$R(t) = 1 - F(t) \tag{4.9}$$

One of the simplest explanation of hazard and failure rate is the analogy made by Airing[2] that "suppose a family takes an automobile trip of 120 miles and completes the trip in three hours. Their average rate was 40mph (120:3), although they drove faster at some times and slower at other times. The rate at any given instant could have been determined by reading the speed indicated on the speedometer at that instant. The 40mph is analogous to the failure rate and the speed at any point is analogous to the hazard rate".

It is worth mentioning that the Weibull distribution is a useful description for h(t) as:

$$h(t) = \frac{n}{\eta^{n}} \cdot t^{n-1} \tag{4.10}$$

where n is called the shape parameter.

With increasing n the Weibull mortality represents a progressively increasing hazard rate characteristic. η is called the scale parameter which stretches the distribution along the time axis.

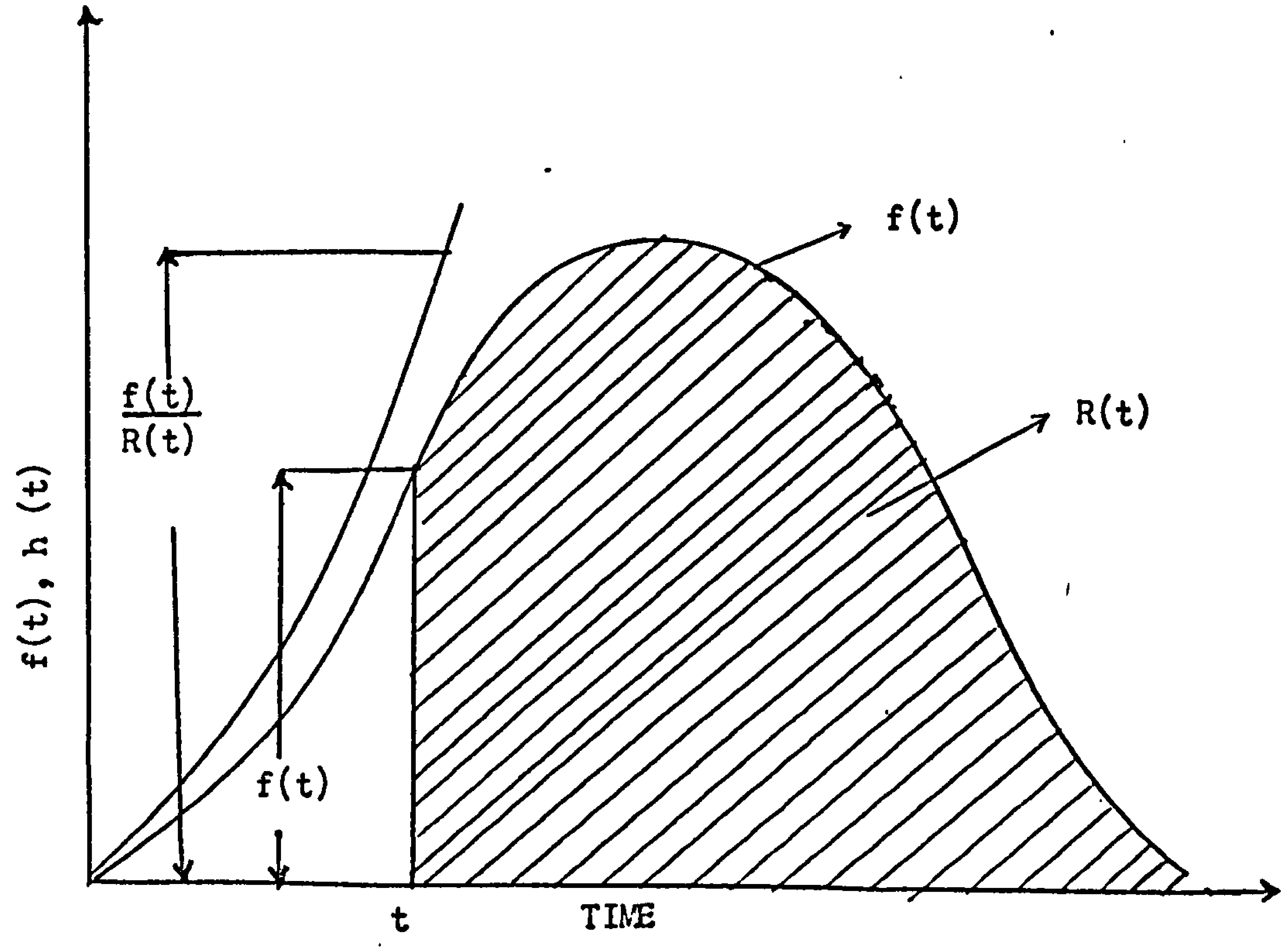


Fig. 4.1 Hazard Rate

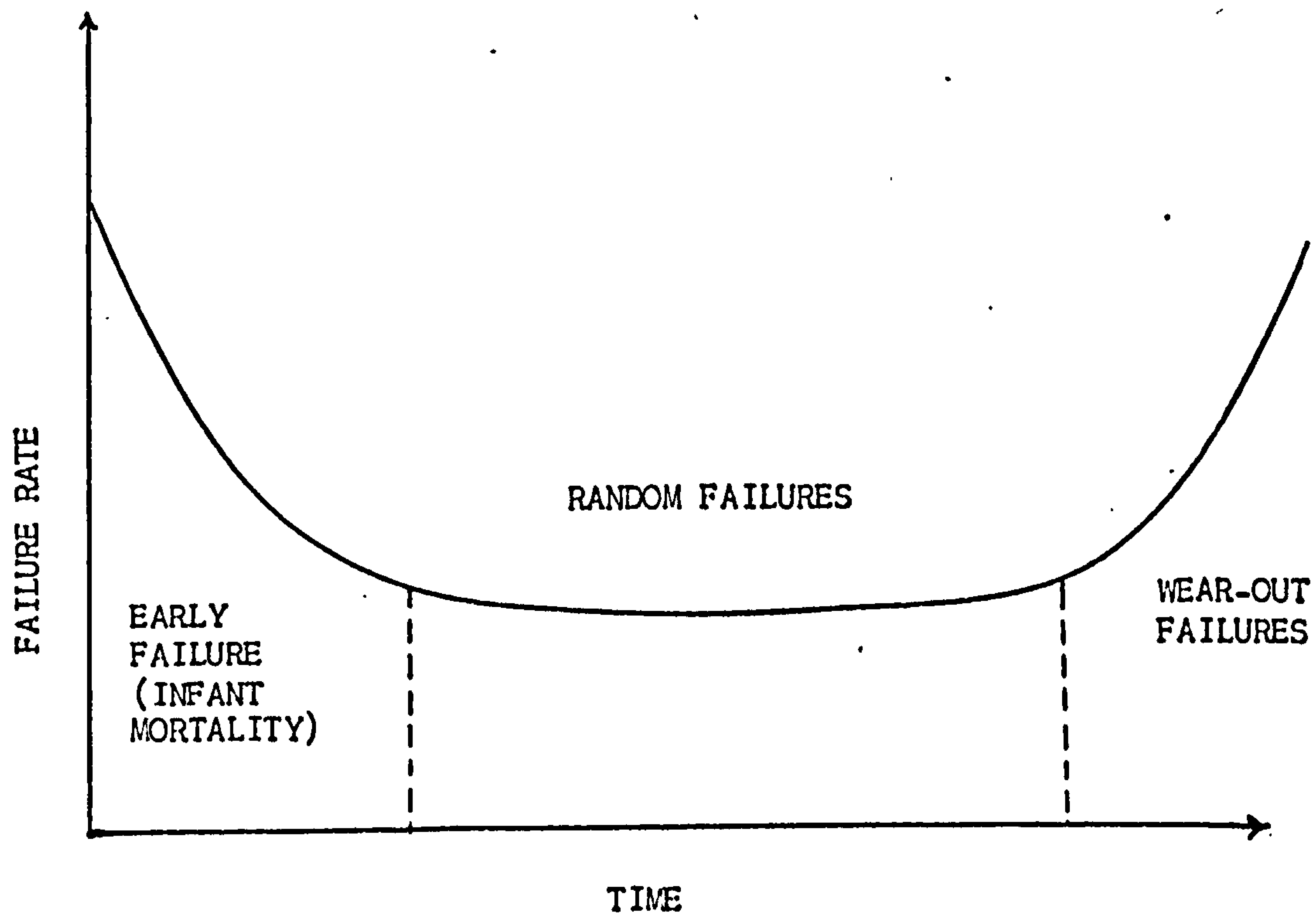


Fig. 4.2 Bath-tub Curve

4.4.4 Bath tub curve

There may be more than one contributory factor or cause to a particular failure and that often there is no completely clear-cut distinction between some of the causes. Nevertheless the time to failure pattern of the components and systems can often be categorised into three groups. These facilitate discussion of the various activities within the discipline of reliability mathematics without invalidating conclusions. One can then investigate problems of prediction, apportionment and assessment and present methods for arriving at solutions to these problems. The three classes of failure are:

1. Infant Mortality

Infant mortality which may be called "running-in" type of failure or 'early failure', are those which often occur during the research and development stage in engineering and manufacturing works. In the present study this would represent the introductory phase of the company life cycle.

2. Random Failure

Random failure is caused mainly by unpredicted failure and seems to have a constant failure rate with no direct cause of failure. The growth and maturity phases of a company life cycle are the representatives of random failure.

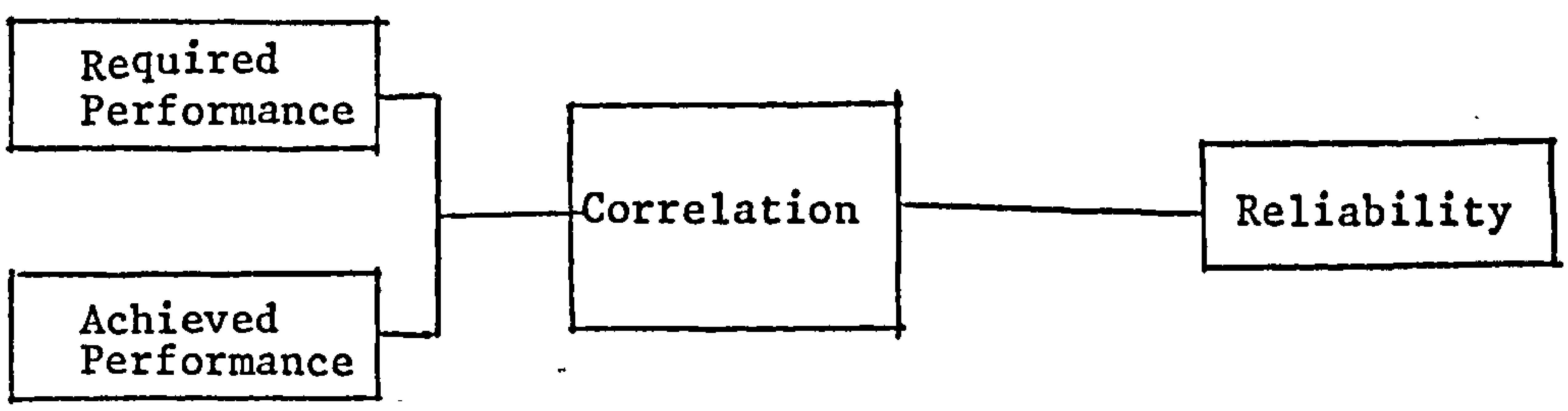
3. Wear-out Failure

Wear-out failure which is caused by ageing of the equipment has an increasing instantaneous failure rate function. This failure can be best represented by the "declining phase" of company life cycle.

The relationship of these three classes of failure can be represented by a "bath tub curve" as shown in Fig. 4.2. It should be noted that the heights of the early and wear-out failure periods, do not necessarily have exactly the same relationship depicted in the figure. The frequency of early failures, for example, might be considerably lower for a mechanical component in the production phase. Similarly, the relative height of the curve in the random failure period might be quite different. However, Fig. 4.2 gives an indication of the general relationship.

4.4.5 Overall reliability

Overall reliability is a measure of the relationship between the complete achieved performance of the system against the corresponding required performance under all the relevant environmental conditions. It may be illustrated by the following block diagram:



Overall Reliability Concept

Under any of the relevant conditions, including any point in space and time, the reliability is the chance of the achieved performance falling within the bounds of the required performance. This is the procedure denoted by the "correlation" in the diagram, and the output of this block leads directly to the measure of reliability.

4.4.6 Failure distributions

A failure distribution represents an attempt to describe mathematically the life behaviour of a device, system or recognisable entity.

The modes of possible failure for the item in question affect the analytic form of distribution used. On the basis of actual observations of times to failure, it is often difficult to distinguish among the various nonsymmetrical probability functions available. Often information such as the failure distribution may not be known; there may be a set of observations of failure times available from historical records. One might wish to decide what class of failure distribution to fit to the observations and what the goodness of fit is.

4.5 Probabilistic Models Describing Failure Behaviour

There are different stochastic and probabilistic models used in reliability assessment in describing failure behaviour. In this chapter the following probability distributions, fundamental to reliability methodology, which have given the best fit for company failure data are examined.

4.5.1 Weibull distribution

The weibull distribution, which is possibly the most popular and versatile model used, was first introduced by a Swedish physicist to describe fatigue failure behaviour.

If the hazard rate of a device or system can be characterised by an expression of the form:

$$h(t) = \frac{n}{\eta} \left(\frac{t-u}{\eta}\right)^{n-1} \qquad (4.11)$$

where

$n, \eta > 0$

$u > 0$

$t > U$

Since:

$$f(t) = h(t).\text{EXP} - \int_{o}^{t} h(t)dt \qquad (4.12)$$

Then $f_t(t)$ for the Weibull distribution is given by:

$$f_t(t) = \frac{n}{\eta}\left(\frac{t-U}{\eta}\right)^{n-1} \cdot \text{EXP} \; -\left(\frac{t-U}{\eta}\right)^{n} \tag{4.13}$$

and the cumulative distribution function by:

$$F_t(t) = 1 - \text{EXP} \; -\left(\frac{t-U}{\eta}\right)^{n} \tag{4.14}$$

$$t > U$$

The reliability function is

$$R(t) = \text{EXP} \; -\left(\frac{t-U}{\eta}\right)^{n} \qquad t > U \tag{4.15}$$

where, in the present study,

n is known as the shape parameter

η the scale parameter or characteristic life

U the location parameter or guaranteed life

The hazard rate for the Weibull distribution for different values of n is:

for $n>1$ it characterises an increasing failure rate

for $0<n<1$ decreasing failure rate behaviour

when $n=1$ the Weibull distribution specialises to the exponential distribution with a constant failure rate.

In reliability studies, the location parameter U can often be taken as zero, in which case:

$$F(t) = 1 - \text{EXP} \; - \left(\frac{t-U}{\eta}\right)^{n} \qquad t>0 \tag{4.16}$$

(4.16) is called two-parameter Weibull distribution.

Conclusions drawn by previous research workers Tia[147], Esfahani[129], and Kamath[91] show that the Weibull fits failure data at least as good as alternative models. The reason is that the shape of the Weibull depends on the value of the n and therefore by choosing the correct value, the Weibull can be fitted to a variety of data.

4.5.2 Log-normal distribution

The log-normal distribution in its simplest form may be defined as the distribution of a variate whose logarithm obeys the normal law of probability.

McAlister appears to have been the first person to set down explicitly and in some detail a theory of the log-normal distribution.

Let t be the time-to-failure random variable of a device, and T = log t be distributed normally with parameters μ and σ. Thus,

$$f_T(t) = \frac{1}{\sigma\sqrt{2\pi}} \cdot \text{EXP} - \tfrac{1}{2}.\left(\frac{t-\mu}{\sigma}\right)^2 \qquad -\infty<t<\infty \qquad (4.20)$$

it follows from the above that the density function of t, $g_t(t)$, is given by:

$$g_t(t) = \frac{1}{\sigma.t\sqrt{2\pi}} .\text{EXP} - \tfrac{1}{2}\left(\frac{\ln t-\mu}{\sigma}\right)^2 \qquad t>0 \qquad (4.21)$$

$$= 0 \text{ elsewhere}$$

This is called log-normal distribution,

where

σ^2 = variance of log t and σ is the shape parameter

μ = scale parameter = mean of log t

To calculate the mean and variance of data, one can use the following formula:

$$\text{Mean of data} = e^{\mu+\frac{1}{2}\sigma^2}$$

$$\text{Variance} = e^{2\mu+\sigma^2}\ (e^{\sigma^2} - 1)$$

4.5.3 Gamma distribution

The gamma distribution can be considered as an extension to the negative exponential distribution and is often used as a model in life-test problems.

Gamma distributions describe a decreasing hazard rate when the shape parameter $\beta<1$, constant hazard rate when $\beta=1$ (exponential), and increasing hazard rate when $\beta>1$.

The probability density function of the gamma distribution is:

$$f(t) = \frac{(t/b)^c.EXP(-t/b)}{b\Gamma(c+1)} \tag{4.17}$$

where

$$\Gamma(c) = \int_0^\infty EXP(-U)U^{c-1}\, dU \tag{4.18}$$

is called gamma function and:

c is called the shape parameter

b is called the scale parameter

The reliability function is easily calculated by

$$R(t) = \int_t^\infty f(t)dt \tag{4.19}$$

4.5.4 Mixed Weibull distribution

The probability density function (pdf) of the bimodal Weibull (mixed Weibull) distribution is defined as

$$f(t) \;=\; \theta f_1(t) + (1-\theta)f_2(t) \qquad (4.22)$$

$$0<t<\infty$$

$$f(t) \;=\; 0 \quad \text{otherwise}$$

where

θ is the proportion of early failures, obviously $0<\theta<1$

$f_1(t)$ and $f_2(t)$ are Weibull probability density functions given by

$$f_j(t) \;=\; \frac{\beta_j t^{\beta_j - 1}}{7_j^{\beta}} \quad \exp(-t/7_j^{\beta_j}) \qquad (4.23)$$

$j = 1,2$ where

1 denotes early failure

2 denotes late failure

$\beta_j>0$ is known as shape parameter of jth type

7_j 0 is known as scale parameter of jth type

By convention, j's are chosen such that

$$7_1 < 7_2$$

a generalisation of which will be

$$f(t) \;=\; \sum_{k=1}^{m} \theta_k \, f_k(t) \qquad (4.24)$$

$0<\theta_k<1$ and

$\sum_{k=1}^{m} \theta_k = 1$

Reliability and hazard rate functions are:

$$R(t) = \theta R_1(t) + (1-\theta)R_2(t) \tag{4.25}$$

where

$$R_j(t) = \exp -(t/\ _j)^{\beta_j} \tag{4.26}$$

$$j=1,2$$

$$h(t) = \frac{f(t)}{R(t)} = \frac{\theta f_1(t) + (1-\theta)f_2(t)}{\theta R_1(t)+(1-\theta)R_2(t)} \tag{4.27}$$

The mathematical behaviour of a bimodal Weibull distribution reduces to a simple Weibull when the proportion parameter θ is equal to zero or one. This distribution was first proposed by Kao in the reliability study of electron tubes. Keller and Kamath[92] later demonstrated its applicability to the failure time analysis of semiconductor devices and in this study it is applied to the analysis of company failure data. A detailed description of the model, estimation of parameters, applications and problems is given by A R R Kamath[91].

4.6 Analysis of Company Failure Data

The analysis of company failure data can be divided into three different parts as follows:

1. Application and validity of statistical distributions.

   In this section various statistical distributions and models used in this study are examined to explain the inherent variation of the company failure times. An attempt has also been made to interpret physically the parameters of the distributions, and the conditions when they can be used.

2. Analysis of company failure data according to the year of failure of companies (1970-1977)
3. Analysis of company failure data according to the groups of companies.

4.6.1 Application and validity of statistical distributions

The distributions considered for the analysis of company failure data are:

1. Weibull
2. Log-normal
3. Gamma
4. Exponential
5. Mixed Weibull

Statistical properties of these distributions have already been discussed.

The method of maximum likelihood was used for the estimation of parameters and Kolmogorov-Smirnov Test was applied to test the goodness of fit for various distributions. Both methods are described in Appendix B.

Three computer programs were used for the estimation of parameters, (App.C) testing the goodness of fit and drawing the plots for 25 ranges of data. The following plots were produced for each group, which are shown in this chapter and in Appendix B.

a. Hazard rate functions

b. Reliability functions

c. Cumulative distribution functions

d. Probability density functions

The specifications of each group for various distributions are tabulated and given; consisting of the parameters of distributions, critical value at 95% significance level and number of companies in the sample.

Table 4.1 gives the Weibull distribution parameter for different groups making up the manufacturing industry. It can be observed from this table that the shape parameters for the group lie between 0.8 and 1.00 representing slowly decreasing or constant hazard rate. This seems to suggest that the companies included in the groups have an almost random failure nature. The Weibull scale parameters of the groups vary a little and lie between 100 and 160 months as given in Table 4.1, with the exception of textile companies which have a scale parameter of 235 months. The reliability and hazard rate plots for the fitted distribution (theoretical) are shown in Figs. 4.3 to 4.30.

From the reliability curves it can be observed that the reliability or probability of survival of companies decreases sharply at the initial stages as can be expected for the value of the parameters that were estimated.

Table 4.2 represents the parameters of the fitted log-normal distribution, the Kolmogorov-Smirnov test statistic, D-Max, and critical values at 95% significance level.

A low value of shape parameter indicates a relatively high proportion of incipient failures. As can be seen from the Table the log-normal shape

TABLE 4.1 Weibull Distribution Parameters of Company Failure Data - Manufacturing Industry

No. of the Sample		D-Max	Shape	Scale	Mean	Critical Values at 5% Significance
A	47	0.09	0.88	130	138.3	0.198
C	48	0.09	1.12	120.7	115.7	0.196
D	35	0.18	1.26	161.3	150	0.23
E	278	0.10	0.96	117.8	119.6	0.082
F	18	0.16	1.18	127.5	120.3	0.32
G	114	0.12	1.00	96	95	0.127
H	44	0.13	0.96	110.6	112.6	0.205
K	42	0.14	0.92	114.1	118.4	0.209
L	150	0.10	0.93	139.7	144.5	0.111
M	88	0.09	0.93	235.2	242.3	0.145
N	35	0.17	0.94	148.1	152.1	0.23
P	277	0.11	0.96	126.6	129	0.081
R	55	0.18	0.93	114.2	118.2	0.183
S	239	0.10	0.96	117.3	119.6	0.088
T	239	0.17	0.89	123.4	130.1	0.088
U	78	0.125	0.97	98	99.4	0.154
All	1787	0.092	0.937	125.6	130	0.032

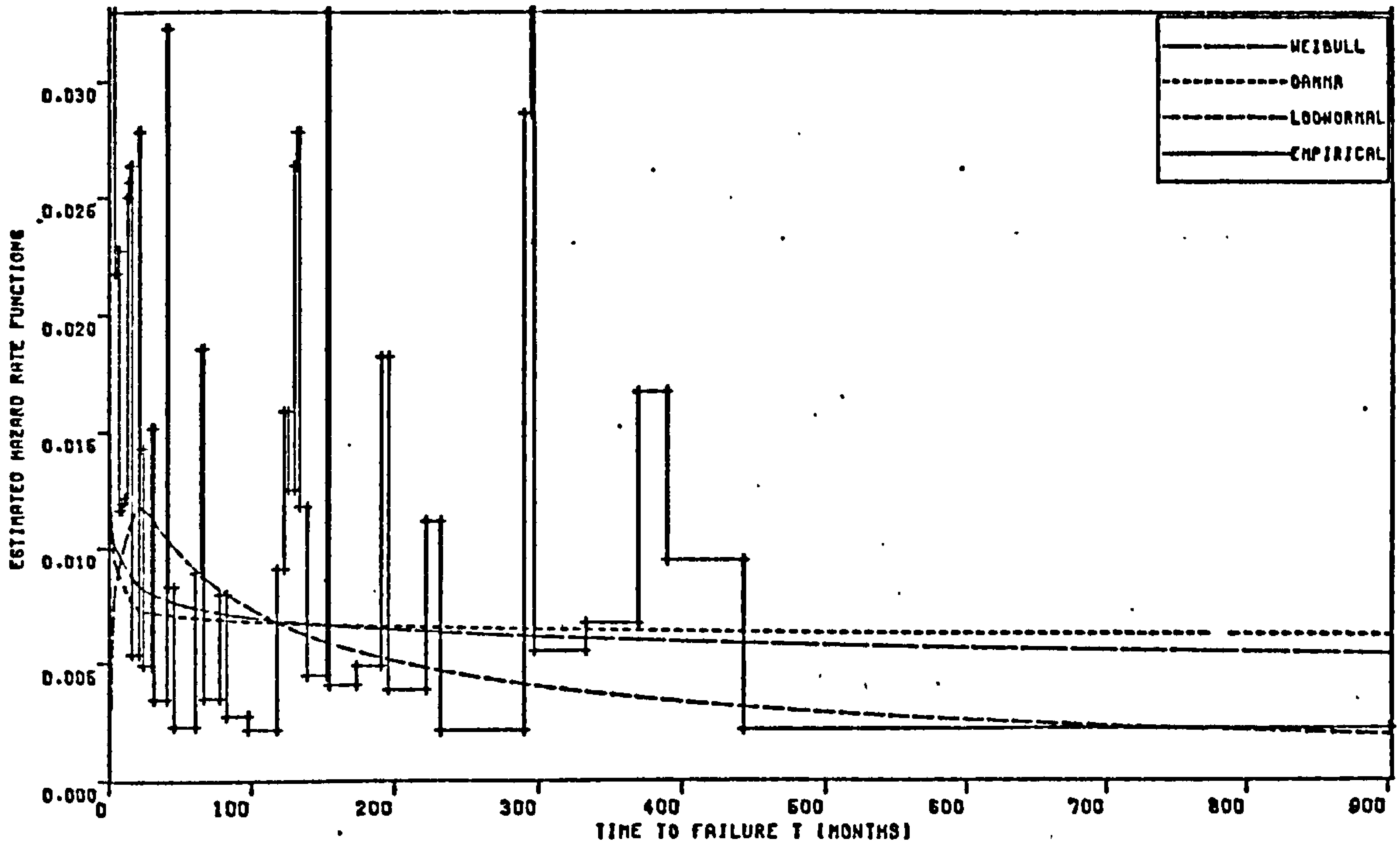


FIG 4.3: HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS
FOOD.DRINK AND TOBACCO

	SHAPE	SCALE
LOG-NORMAL	1.33	4.23
WEIBULL	0.88	130.00
GAMMA	0.73	190.00

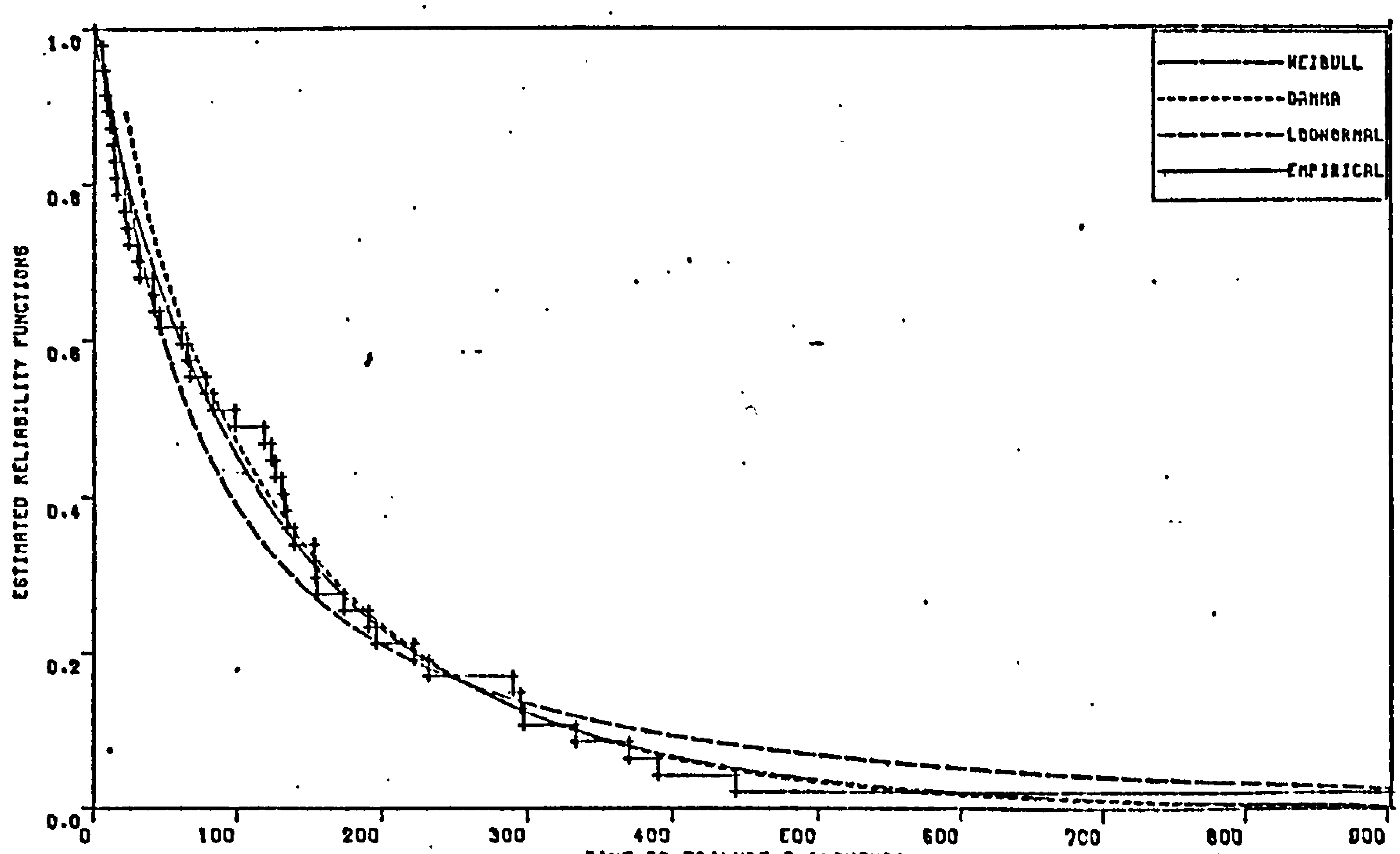


FIG 4.4: RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS
FOOD.DRINK AND TOBACCO

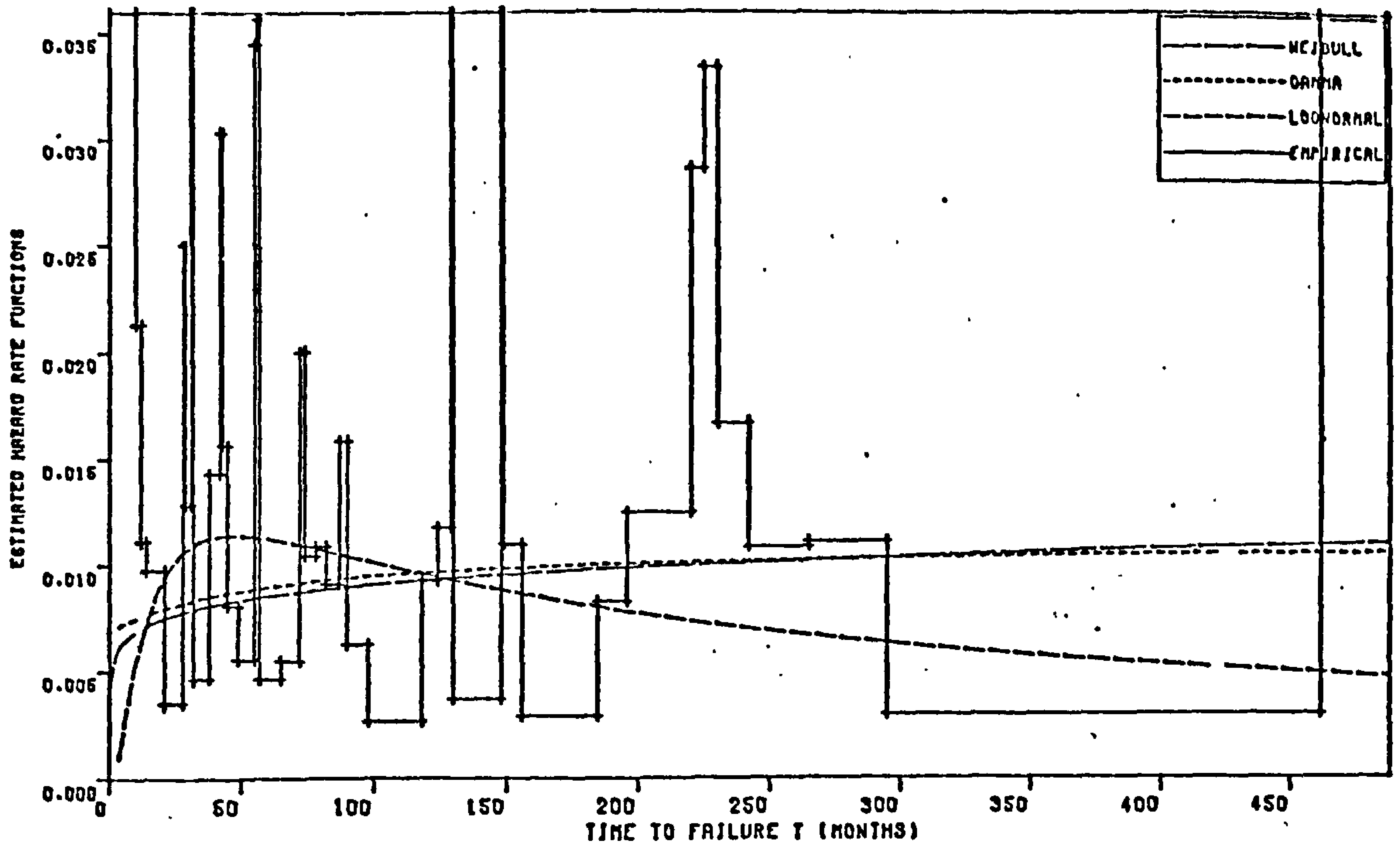


FIG 4.5: HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

CHEMICALS AND ALLIED INDUSTRIES

	SHAPE	SCALE
LOG-NORMAL	0.99.	4.31
WEIBULL	1.12	121
GAMMA	1.11	104

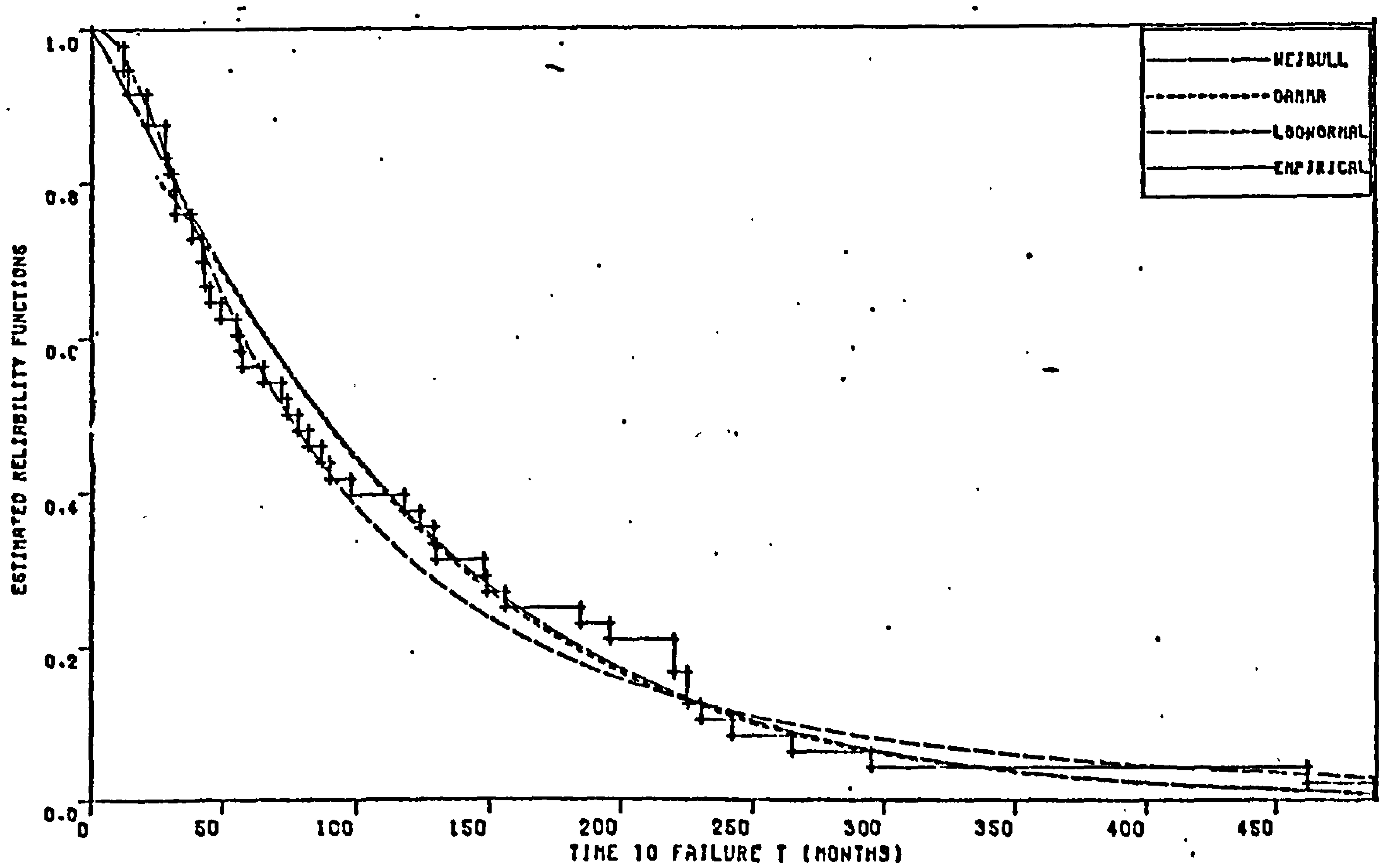


FIG 4.6 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

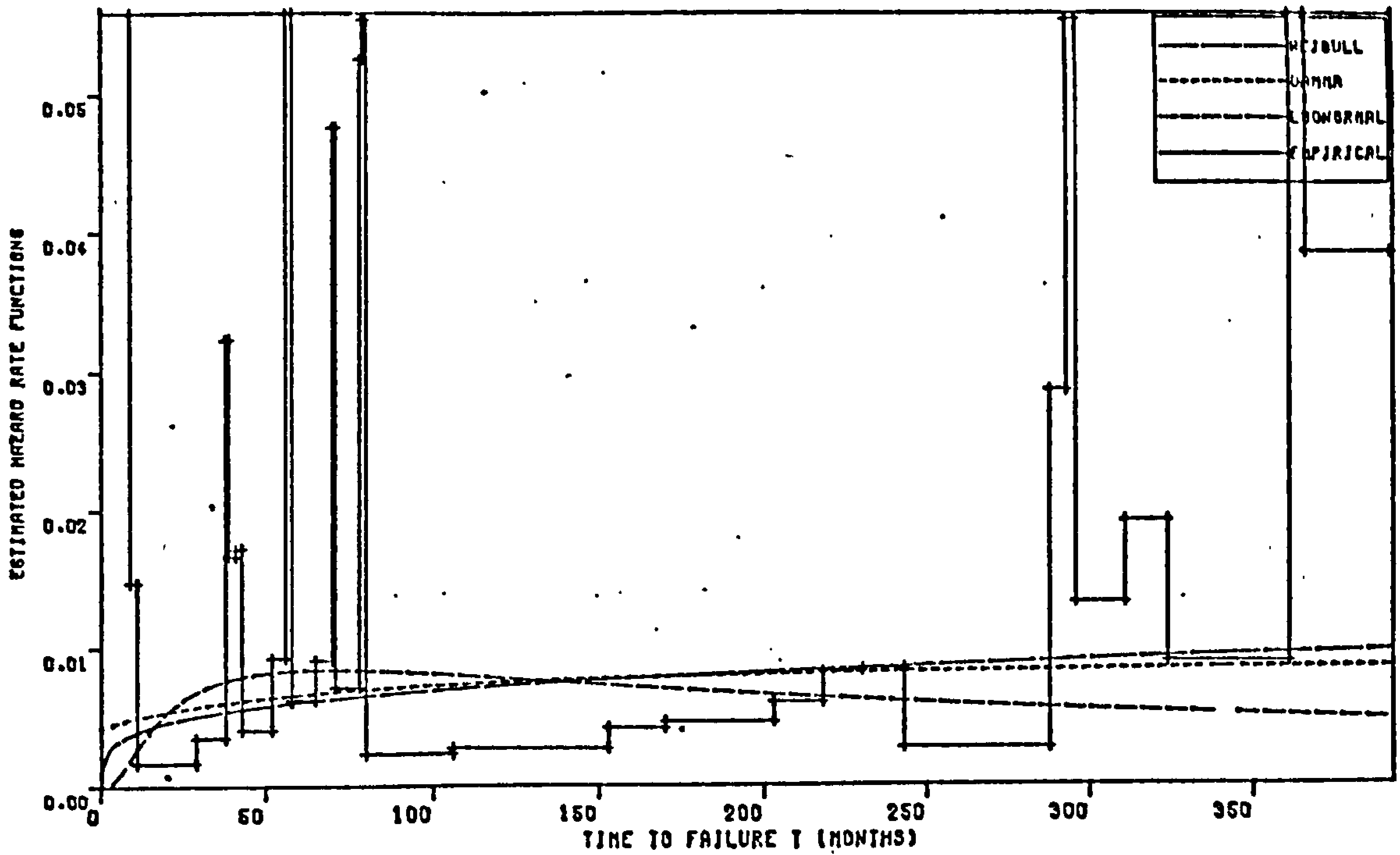


FIG4.7: HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

METAL MANUFACTURE

	SHAPE	SCALE
LOG-NORMAL	0.97	4.62
WEIBULL	1.26	161
GAMMA	1.61	93

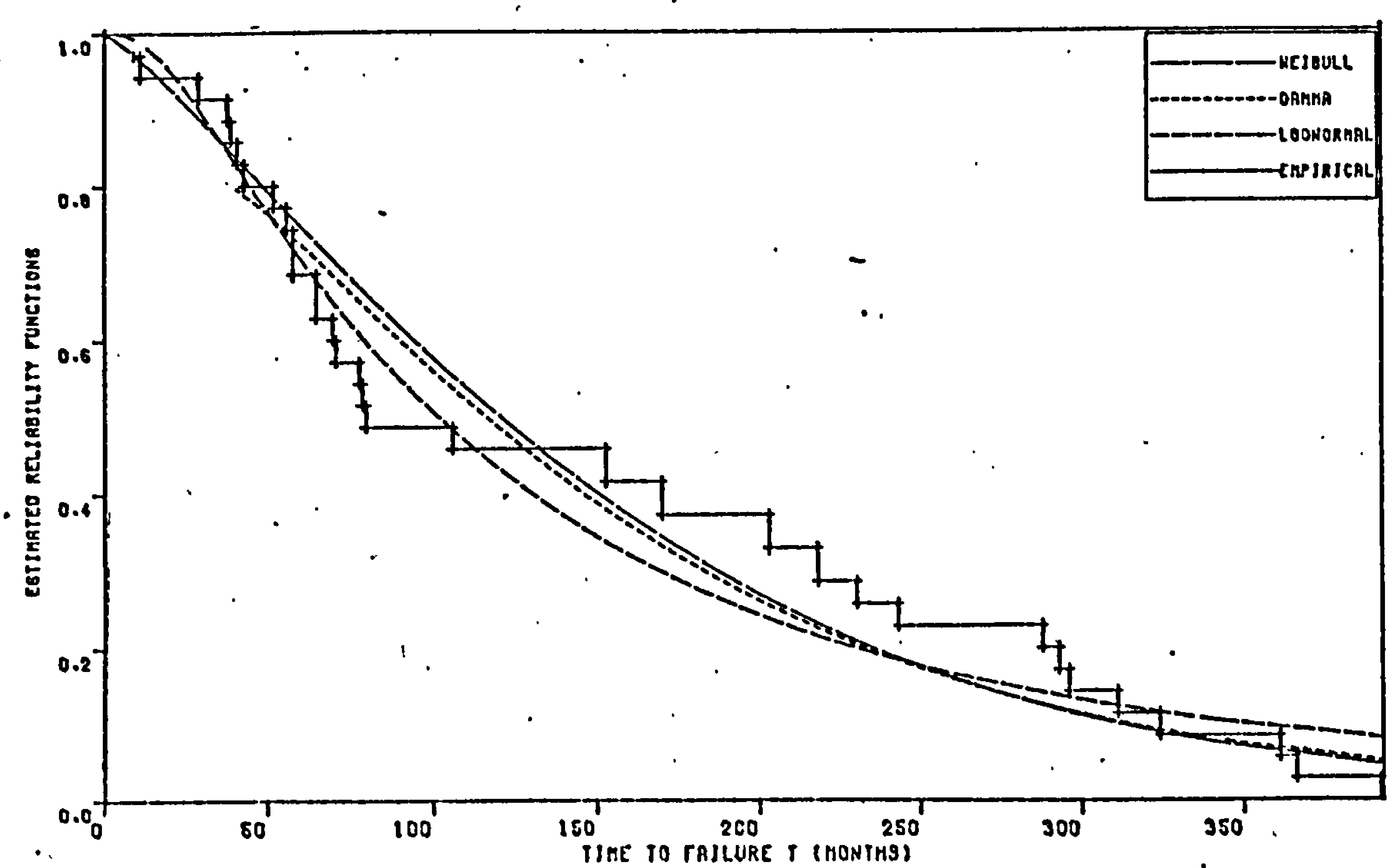


FIG4.8 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

TABLE 4.2 Log-Normal Distribution Parameters of Company Failure Data - Manufacturing Industry

Group of Industry	No. of the Sample	D-Max	Shape Param.	Scale Param.	Mean	Critical Values at 95% Sign.
Food, Drink and Tobacco	47	0.146	1.33	4.23	167.5	0.198
Chemicals and Allied Inds.	48	0.076	0.99	4.31	120.9	0.196
Metal Manufacture	35	0.133	0.97	4.62	162.7	0.23
Mechanical Eng.	278	0.053	1.03	4.24	118.2	0.082
Instrument Eng.	18	0.11	0.92	4.39	123.3	0.32
Electrical Eng.	114	0074	0.91	4.08	-	0.127
Shipbuilding & Marine	44	0.10	1.03	4.18	110.4	0.205
Vehicles	42	0.096	1.06	4.19	116.4	0.209
Metal Goods	150	0.058	1.04	4.40	141.4	0.111
Textiles	88	0.089	1.21	4.87	270	0.145
Leather, Leather goods and Fur	35	0.155	1.10	4.43	155	0.23
Clothing	277	0.076	1.10	4.29	133.8	0.081
Bricks, Pottery Glass & Cement	55	0.13	1.00	4.21	111	0.183
Timber & Furniture	239	0.066	1.09	4.21	122.8	0.088
Paper, Printing & Publishing	239	0.064	1.09	4.25	128.3	0.088
Other Manufacturing	78	0.088	1.04	4.05	99	0.154
All Groups	1787	0.041	1.08	4.28	-	0.032

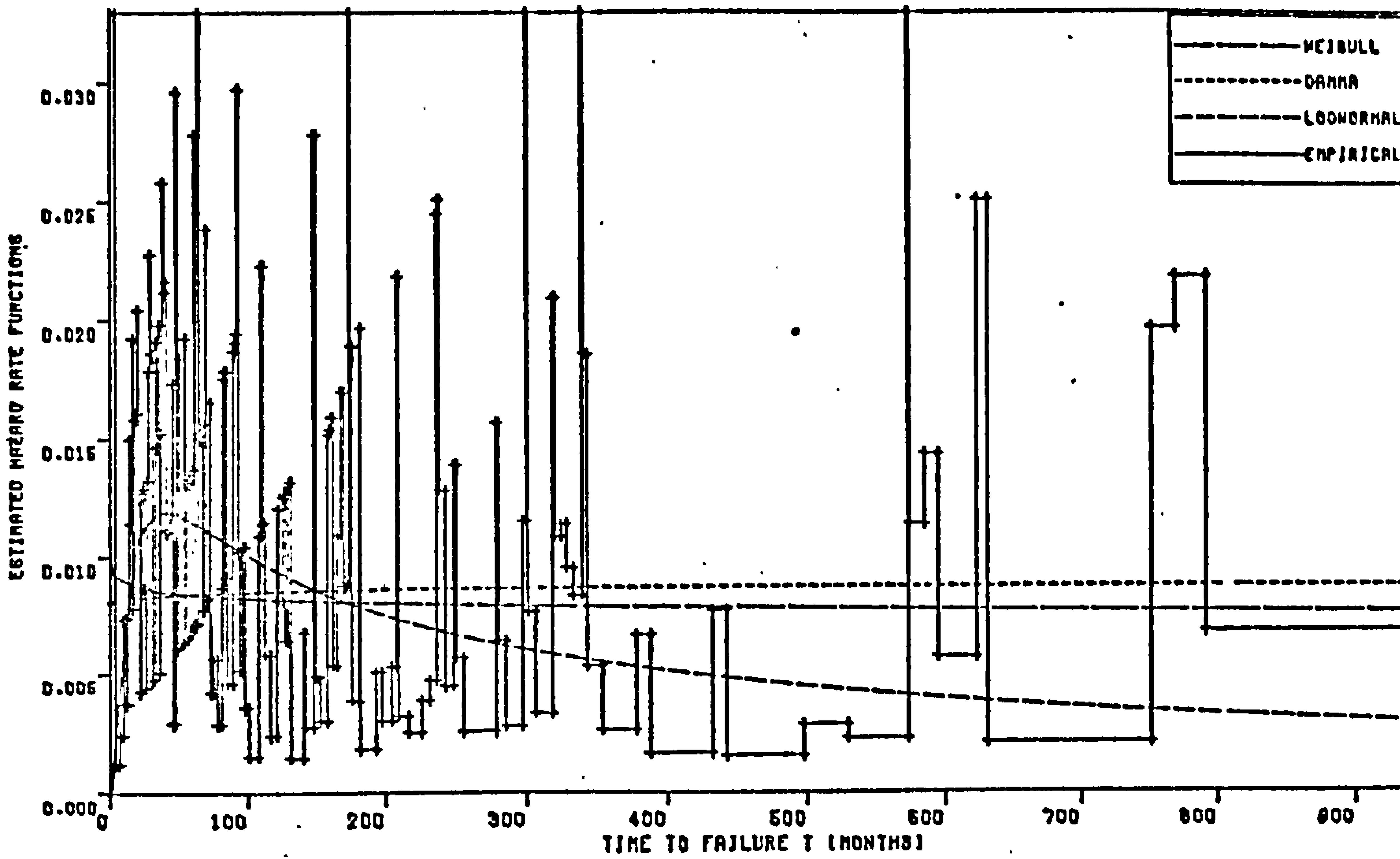


FIG4.9: HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MECHANICAL ENGINEERING

	SHAPE	SCALE
LOG-NORMAL	1.03	4.24
WEIBULL	0.96	117
GAMMA ---	0.66	181

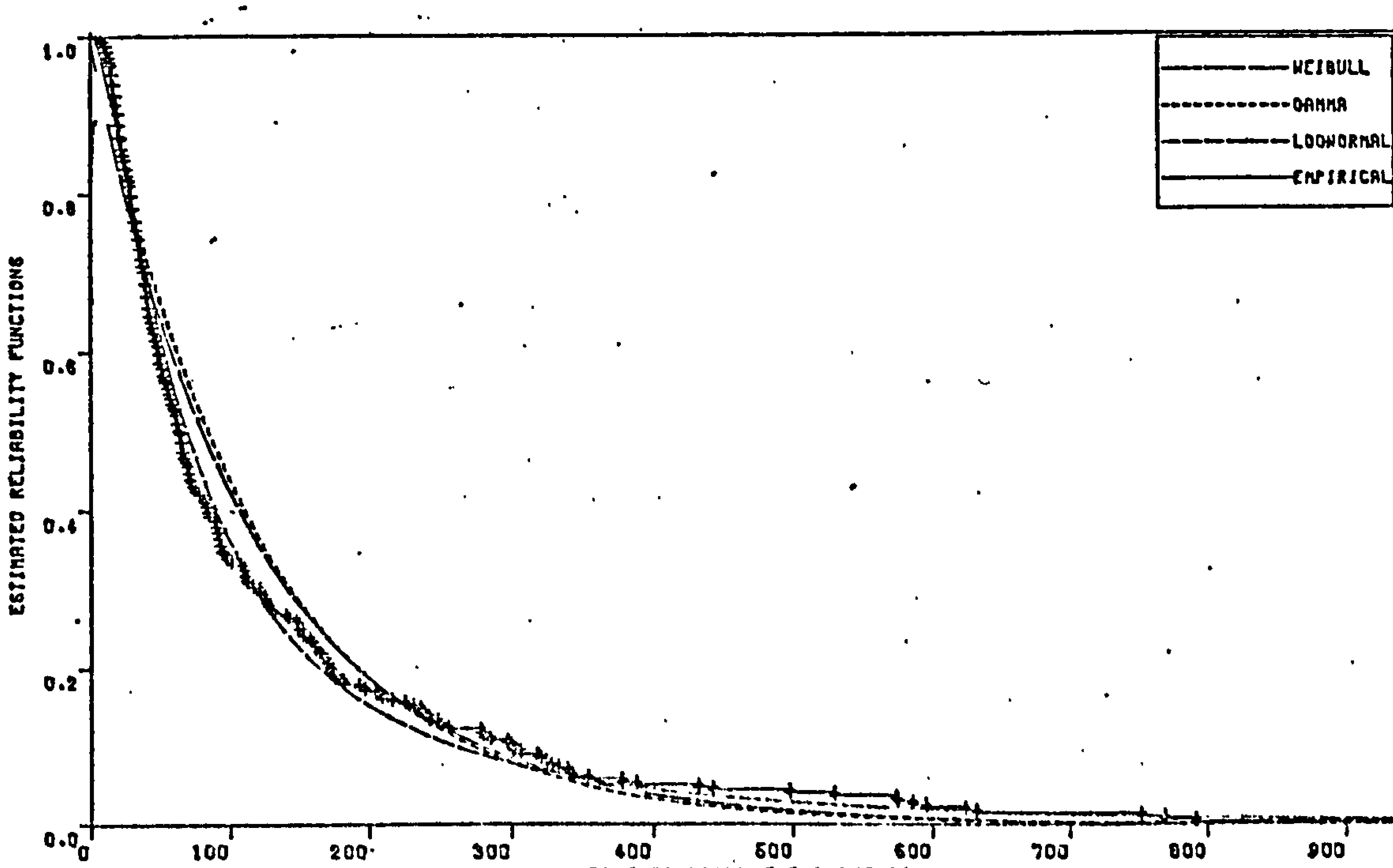


FIG 4.10 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

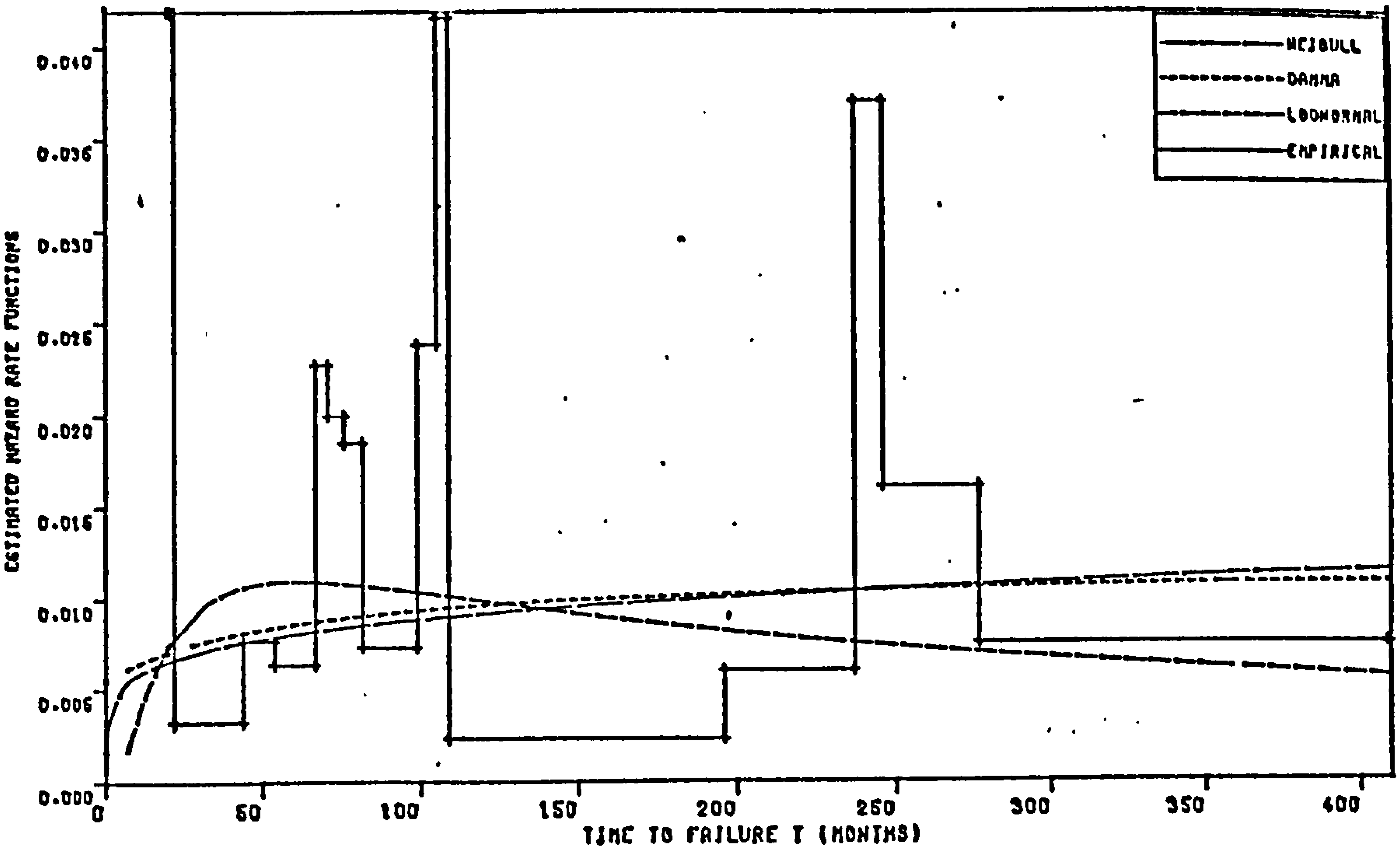


FIG4.11 HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

INSTRUMENT ENGINEERING

	SHAPE	SCALE
LOG-NORMAL	0.92	4.39
WEIBULL	1.18	128
GAMMA	1.21	99

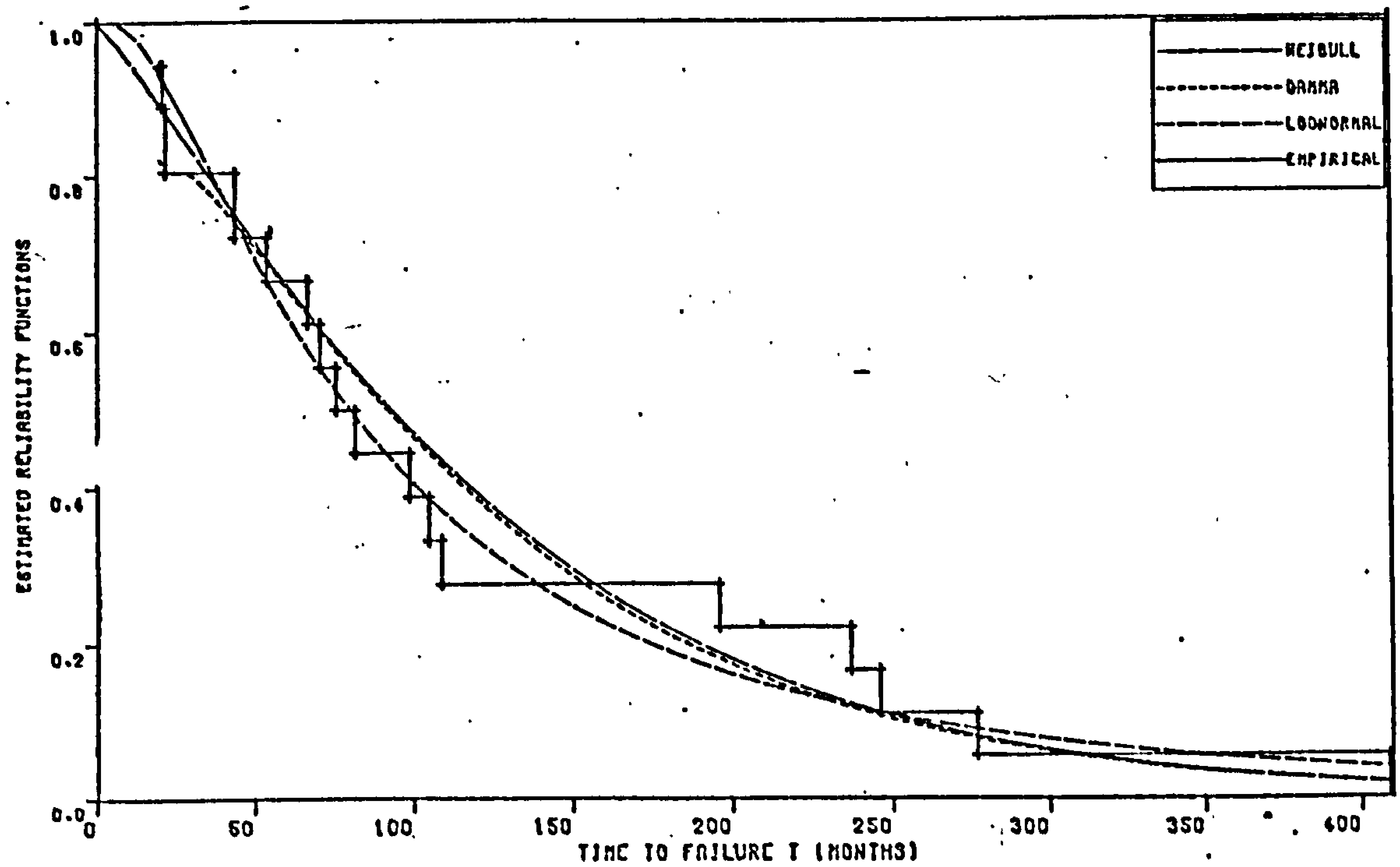


FIG4.12 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

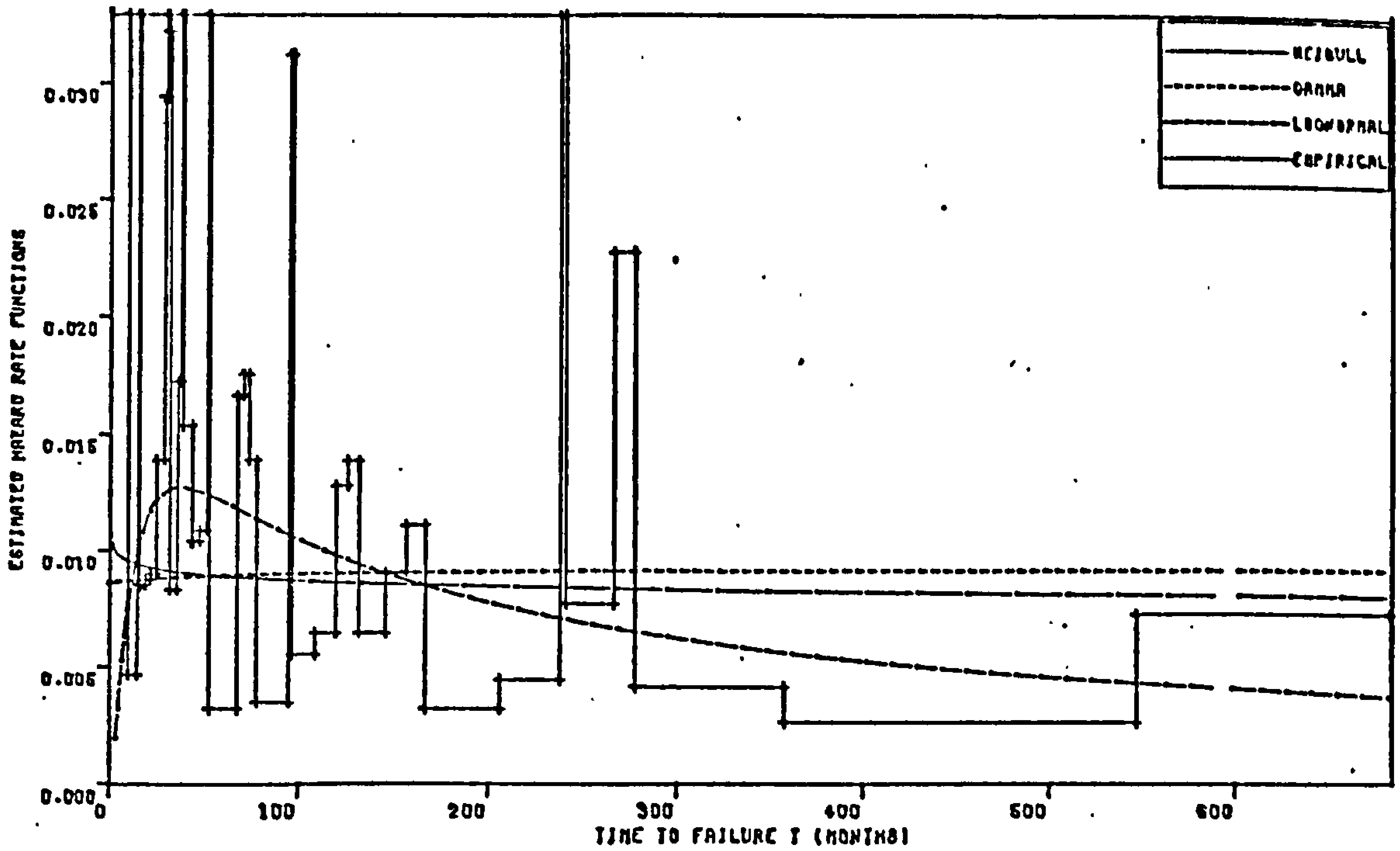


FIG4.13 HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS.

SHIPBUILDING AND MARINE ENGINEERING

	SHAPE	SCALE
LOG-NORMAL	1.06	4.19
WEIBULL	0.96	111
GAMMA	0.65	172

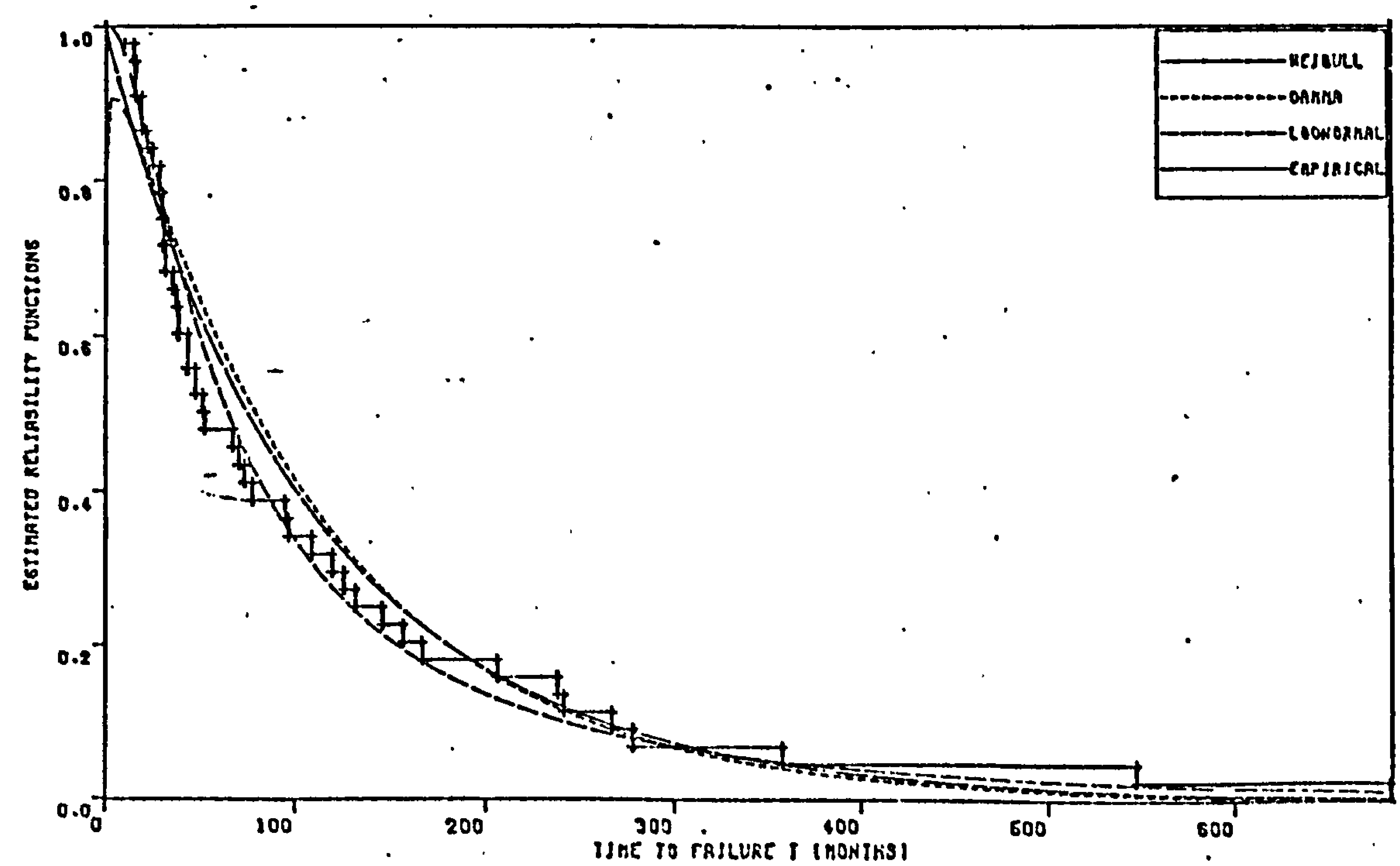


FIG4.14 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

parameters (which is related to variance) of companies in different groups vary between 0.92 to 1.33 indicating that the groups have a similar failure behaviour.

One of the typical characteristics of log-normal distribution is that it exhibits increasing hazard rate at the initial stage of life followed by a gradual decrease.

The sample hazard rate plots shown in Figs. 4.3 to 4.30 corresponding to the groups do not disagree with the possibility of having a relatively high infant mortality at the initial stages of company formation. These include new and usually small businesses which fail due to factors such as lack of experience, working capital and inability to compete in a free competitive market.

If for any particular group the parameters of the log-normal distribution are available, one can determine the time at which the hazard rate starts decreasing. This effectively would give some indication of that time beyond which the company would withstand the risk of failure with age.

Referring to Table 3.12 one can observe a decreasing trend of numbers of company failure after the first three to four years of their lives. This indicates that the first three years as the highest risk interval for the manufacturing companies examined.

The fitted log-normal reliability functions for the companies (Figs. 4.3 to 4.30) show that in most of the cases log-normal distribution gives a better fit to the sample reliability functions. Table 4.3 gives the gamma distribution parameters, K.S. test statistics, D-Max and the corresponding critical values at 5% confidence level for each group. As mentioned earlier in the chapter, gamma distribution characterises monotonically increasing hazard rate for the shape parameters greater

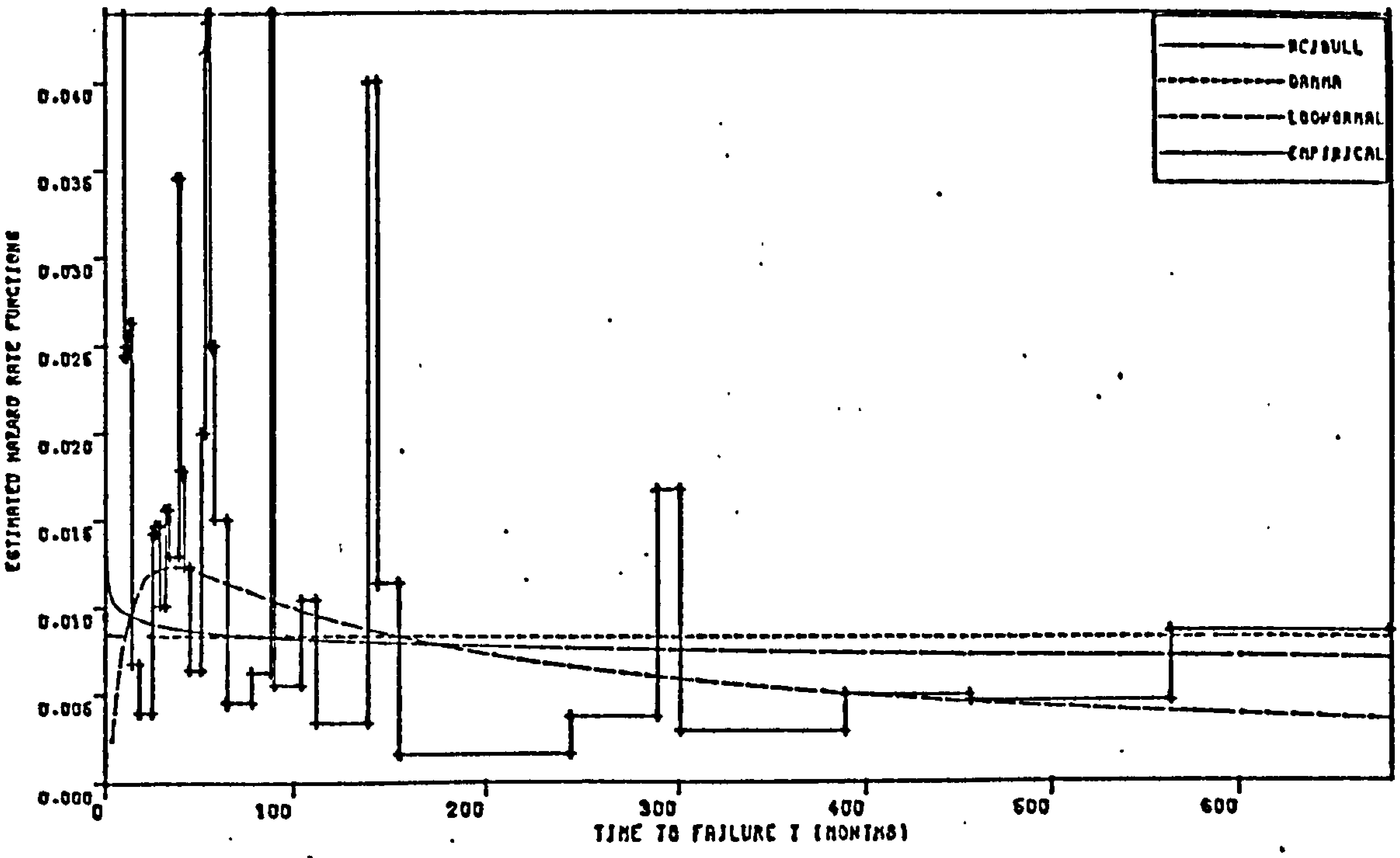


FIG4.15 HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

VEHICLES

	SHAPE	SCALE
LOG-NORMAL	1.06	4.19
WEIBULL	0.92	114
GAMMA	0.61	196

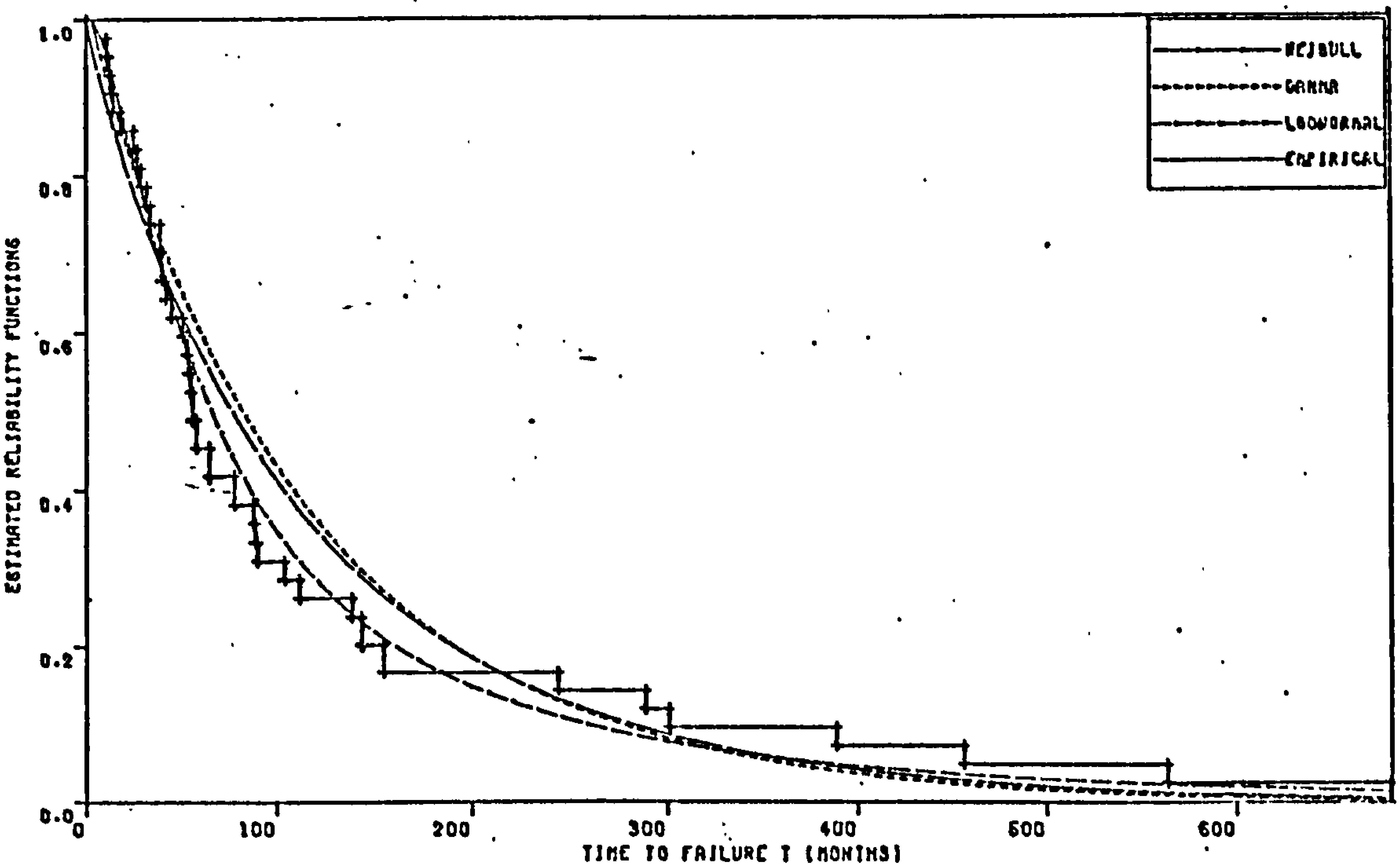


FIG4.16 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

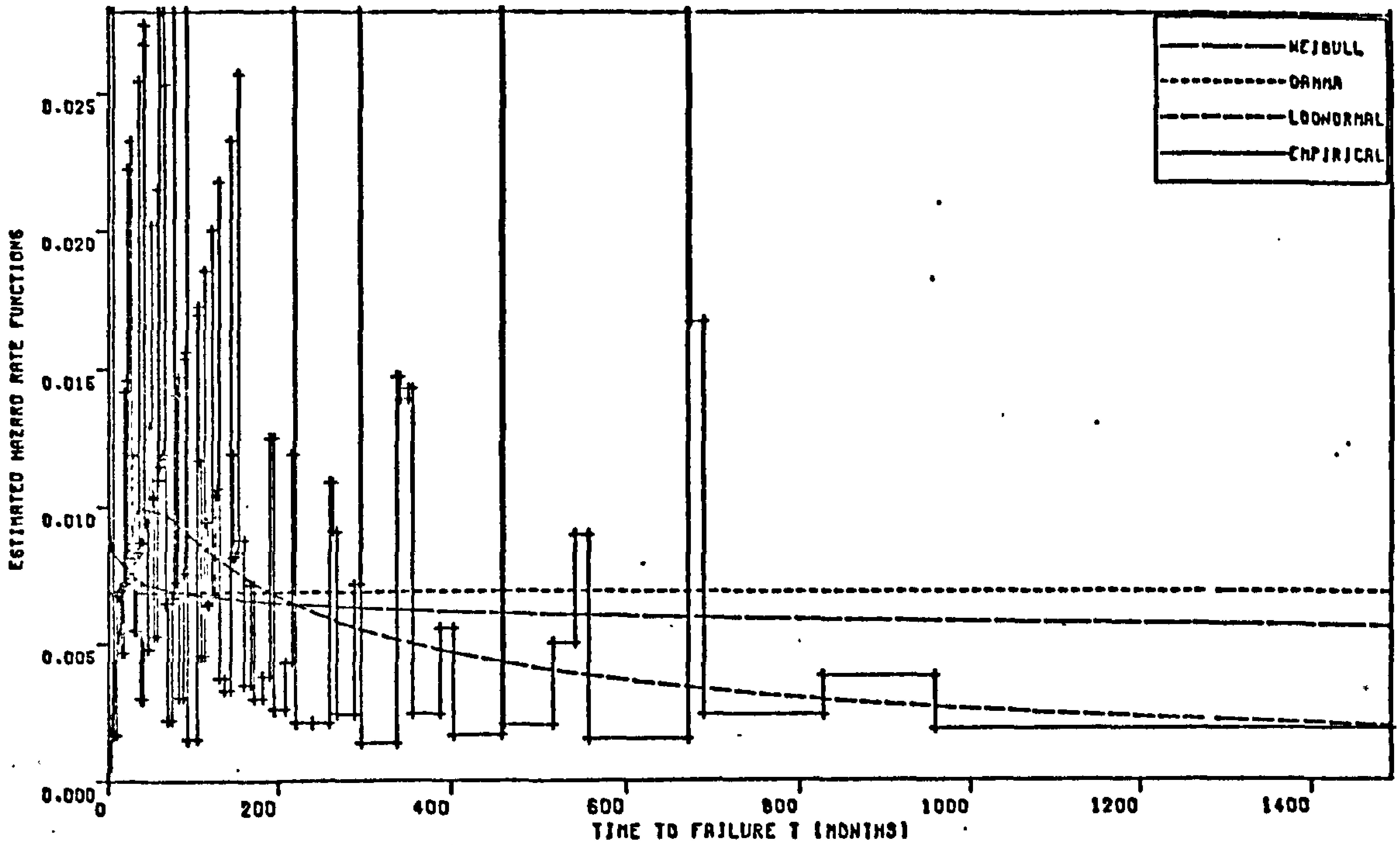


FIG4.17 HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

METAL GOODS

	SHAPE	SCALE
LOG-NORMAL	1.04	4.40
WEIBULL	0.93	140
GAMMA	0.54	270

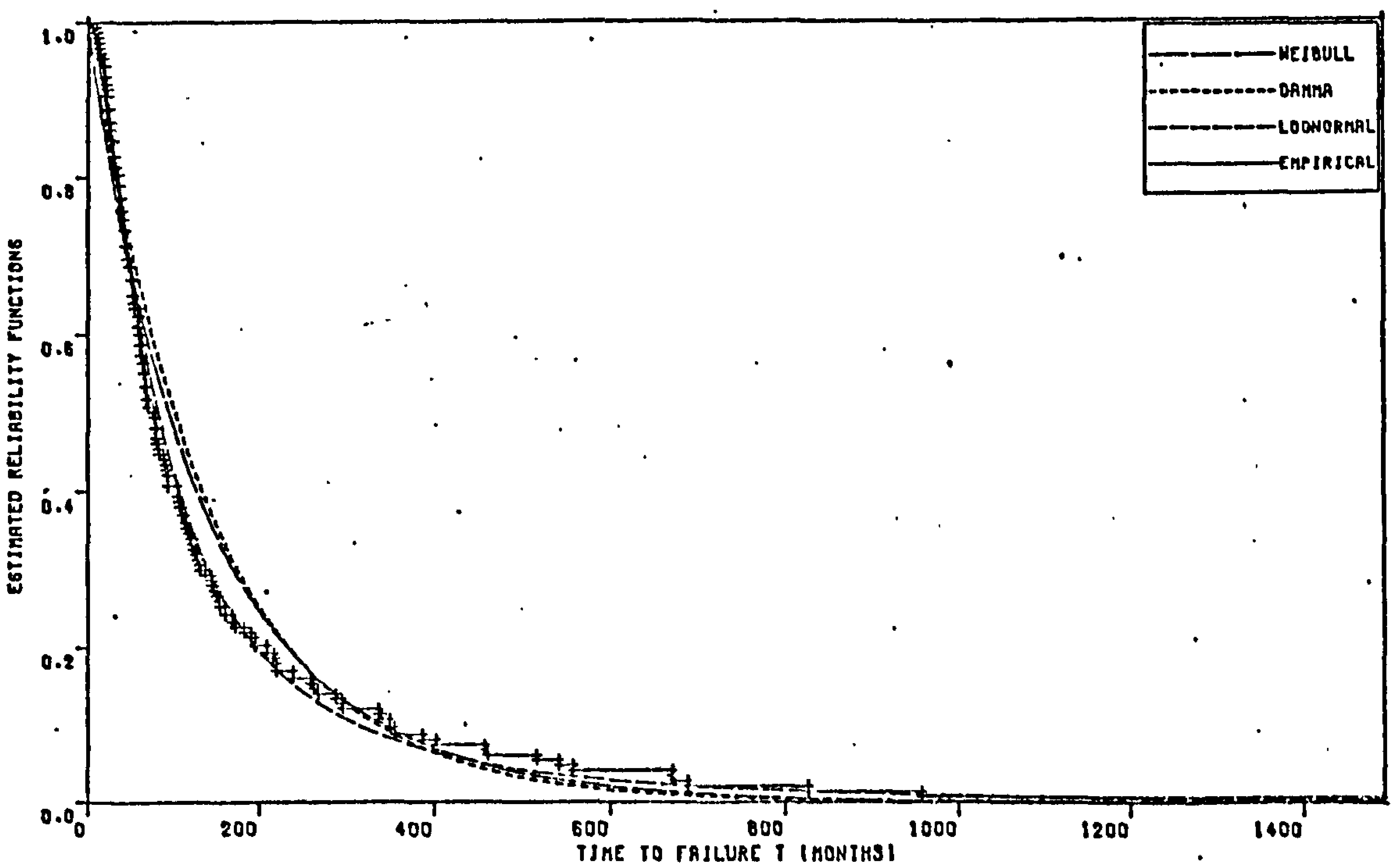


FIG4.18 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

TABLE 4.3 Gamma Distribution Parameters of Company Failure Data ÷ Manufacturing Industry

Group of Industry	No. of the Sample	D-Max	Shape Param.	Scale Param.	Mean	Critica Values at 95% Sign.
Food, Drink & Tobacco	47	0.175	0.73	189.8	138.5	0.198
Chemical and Allied	48	0.18	1.11	103.5	115.4	0.196
Metal Manufacture	35	0.26	1.61	93.3	149.9	0.23
Mechanical Eng.	278	0.12	0.66	181.1	119.9	0.082
Instrument Eng.	18	0.15	1.21	99.2	119.8	0.32
Electrical Eng.	114	0.23	0.59	161	-	0.127
Shipbuilding & Marine	44	0.154	0.65	172.3	113	0.205
Vehicles	42	0.16	0.61	195.8	119.2	0.209
Metal Goods	150	0.12	0.54	269.6	145.5	0.111
Textiles	88	0.11	0.90	268.3	242.6	0.145
Leather, Leather Goods & Fur	35	0.19	0.80	190	152.5	0.23
Clothing & Footwear	279	0.12	0.76	170	129.4	0.081
Bricks, Pottery, Glass & Cement	55	0.21	0.59	199.8	119	0.183
Timber & Furniture	239	0.11	0.80	149.3	119.9	0.088
Paper, Printing & Publishing	239	0.13	0.56	234.7	131.4	0.088
Other Manufacturing	78	0.14	0.70	141.1	99.6	0.154
All Manufacturing	1787	0.14	0.66	198.1	-	0.032

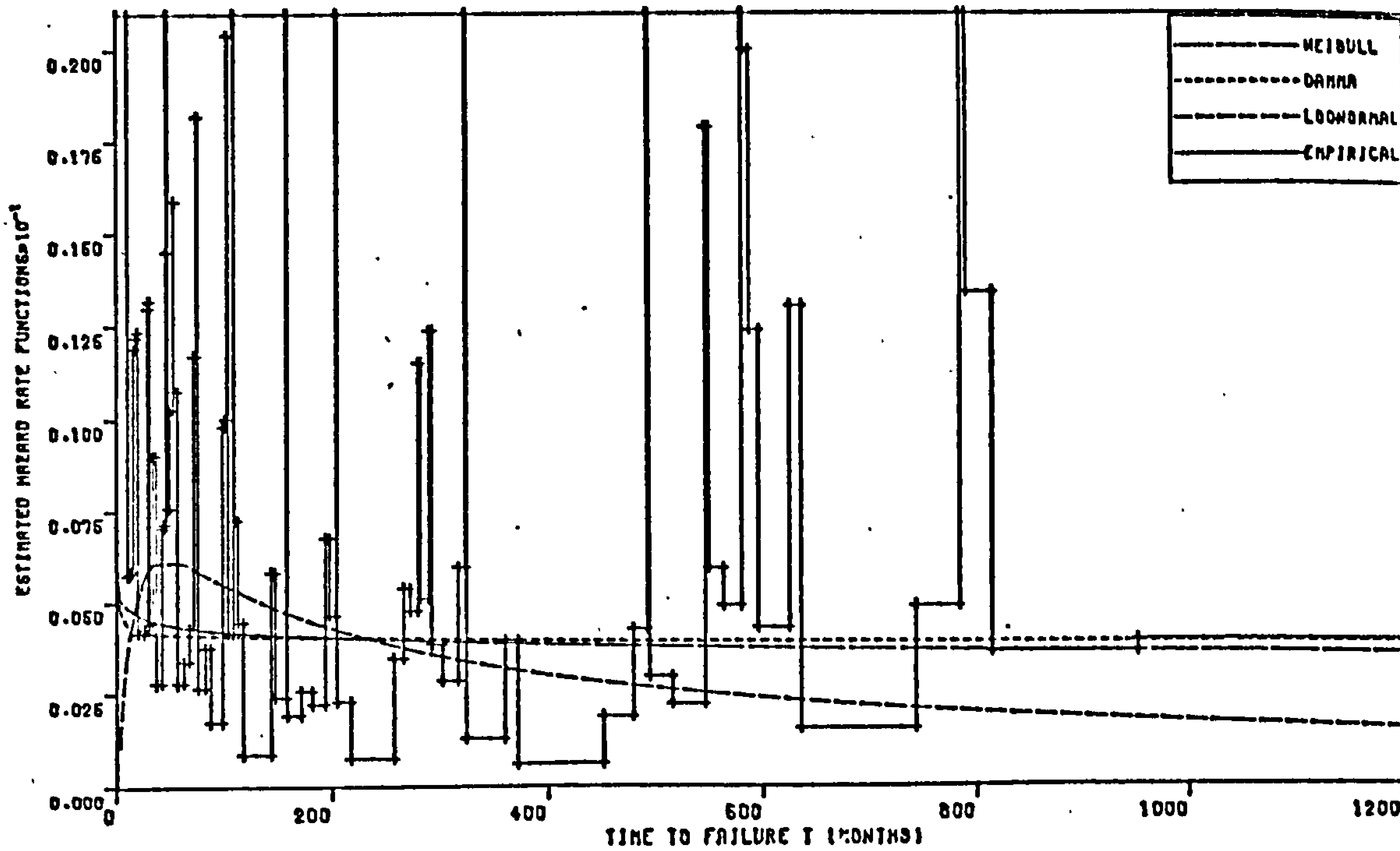


FIG 4.19 HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

TEXTILES

	SHAPE	SCALE
LOG-NORMAL	1.21	4.87
WEIBULL	0.93	235
GAMMA	0.90	268

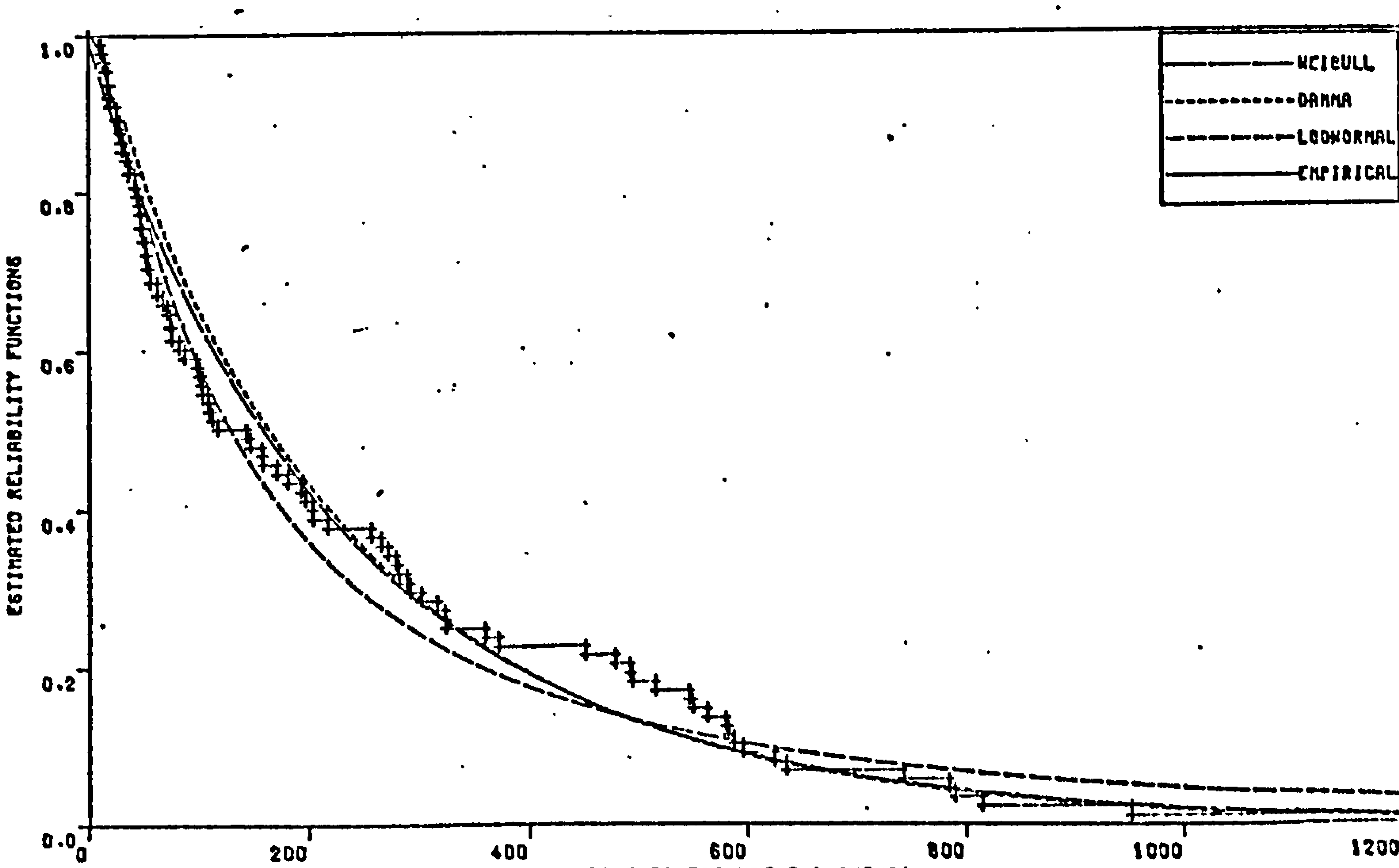


FIG4.20 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

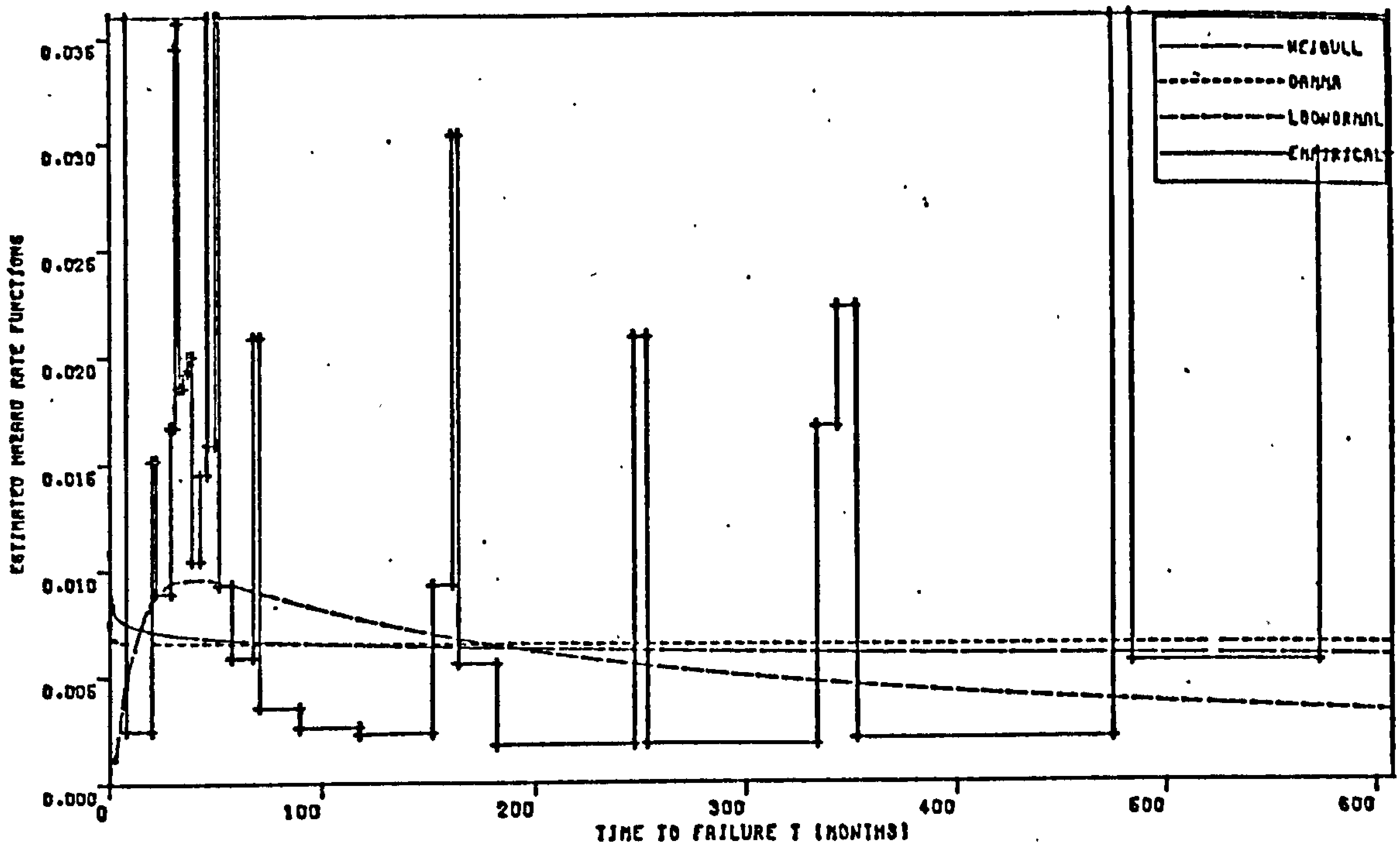


FIG 4.21 HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

LEATHER, LEATHER GOODS AND FUR

	SHAPE	SCALE
LOG-NORMAL	1.10	4.43
WEIBULL	0.94	148
GAMMA	0.80	190

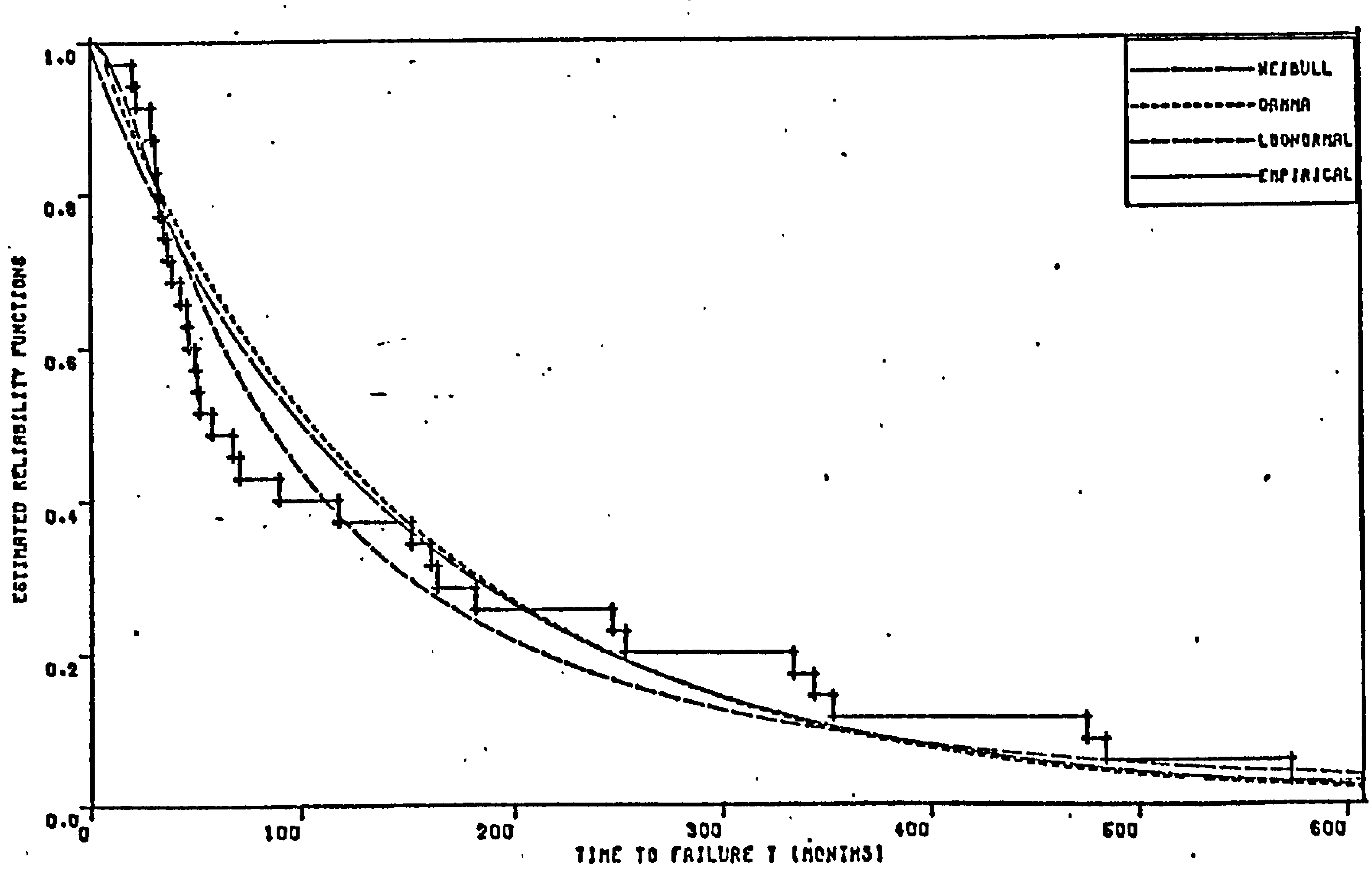


FIG4.22 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

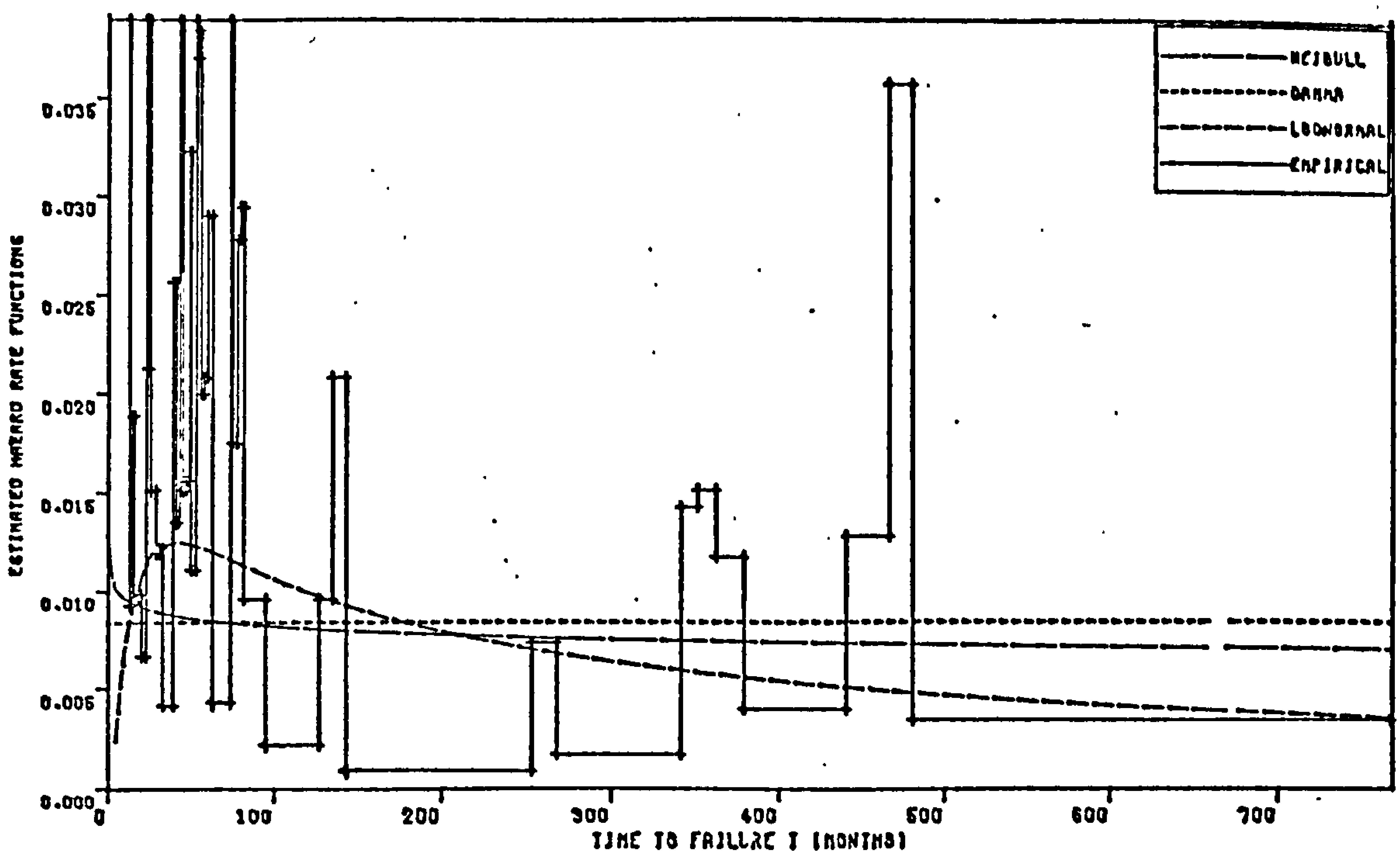


FIG 4.23 HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

BRICKS, POTTERY, GLASS, CEMENT, ETC.

	SHAPE	SCALE
LOG-NORMAL	1.00	4.21
WEIBULL	0.93	114
GAMMA	0.59	200

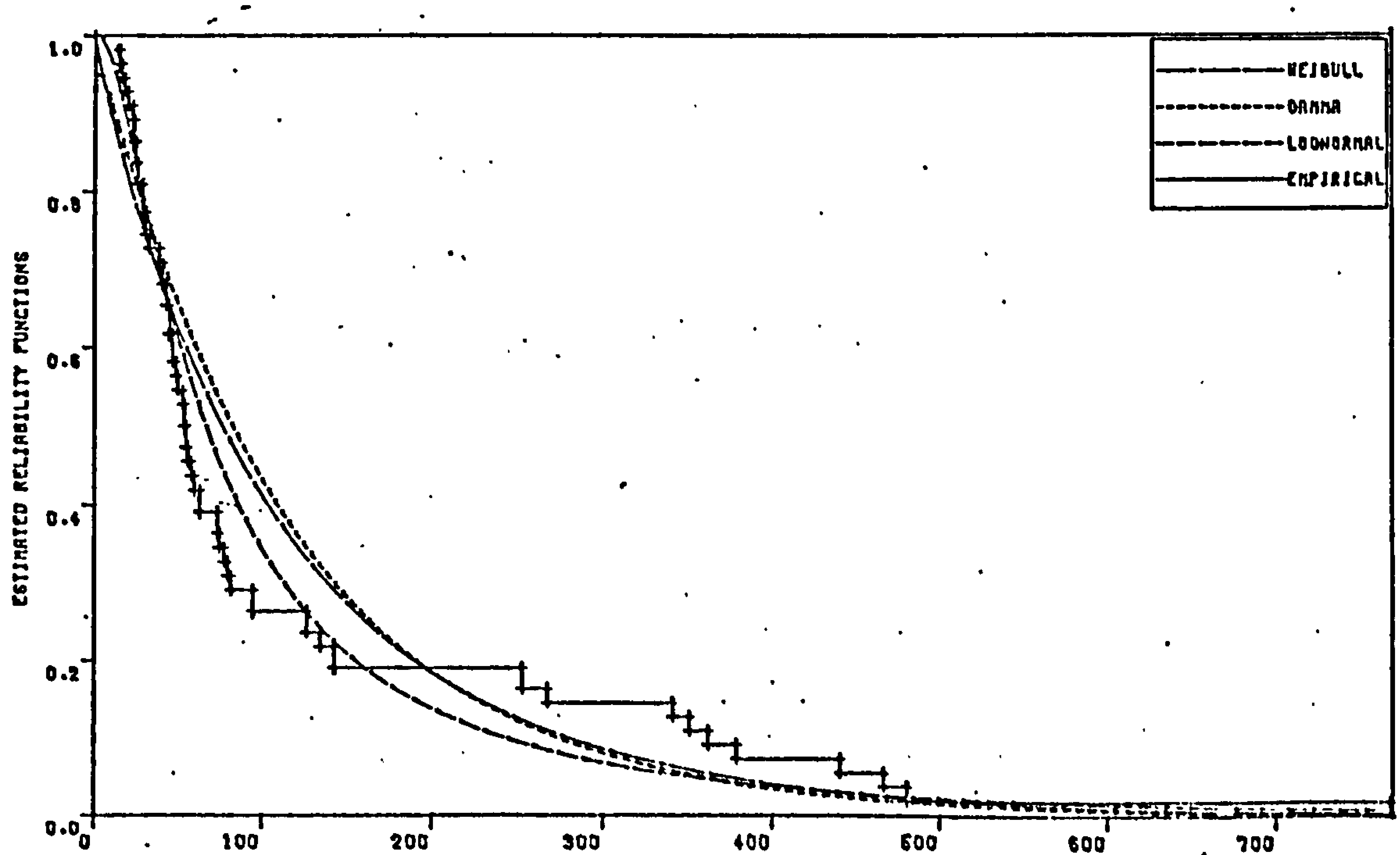


FIG 4.24 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

than 1.00,-and monotonically decreasing for the shape parameters less than 1.00. In both cases, the hazard rate asymptotically approaches exponential failure rate (constant hazard rate = $\frac{1}{\text{scale parameters}}$). This distribution would be ideal in the application of company failure analysis if the failure of companies is necessarily due to accumulated causes and also if one has a reason to believe these causes were random with the same distribution. As can be seen from the Table 4.3, most of the shape parameters corresponding to the manufacturing industry groups have a value of less than 1.00. Corresponding hazard rate plots shown in Figs. 4.3 to 4.30 are almost constant representing nearly exponential failure characteristics. From these results one can only infer that the gamma distribution can be chosen as the appropriate one, when a company fails randomly. Figs. 4.3 to 4.30 give the fitted reliability curves which show the decreasing nature of probability of survival of companies with age, for gamma distribution. As can be seen from the plots, the rate of decrease at the latest stages are comparatively lower than the initial stages. This distribution seems plausible in the case of company failure, since there is an asympthatic positive limit for the conditional failure rate.

Table 4.4 summarises the results of analysis of company failure data using exponential distribution. This includes K.S. test statistics, D-Max, and critical values at 95% significance level for each group. As can be observed from the table, the values of scale parameters do not differ significantly from the Weibull scale parameters (Table 4.1). This distribution would only be acceptable for the company failure data if one has the reason to believe failure is purely random. However, from the sample hazard rate it would be difficult to explain the relatively high hazard rate exhibited at the beginning using the exponential distribution.

TABLE 4.4 Exponential Distribution Parameters of Company Failure Data - Manufacturing Industry

Group of Industry	No. of Sample	D-Max	Scale Parameter	Critical Values at 95% Significance
Food, Drink & Tobacco	47	0.112	138.5	0.198
Chemicals & Allied	48	0.064	115	0.196
Metal Manufacture	35	0.112	150	0.23
Mechanical Eng.	278	0.114	120	0.082
Instrument Eng.	18	0.101	120	0.32
Electrical Eng.	114	0.119	95	0.127
Shipbuilding & Marine	44	0.136	113	0.205
Vehicles	42	0.161	119	0.209
Metal Goods	150	0.124	145	0.111
Textiles	88	0.113	242	0.145
Leather, Leather Goods & Fur	35	0.183	182	0.23
Clothing & Furniture	277	0.106	127	0.081
Bricks, Pottery, Glass & Cement	55	0.198	119	0.183
Timber & Furniture	239	0.116	120	0.088
Paper, Printing & Publishing	239	0.136	131	0.088
Other Manufacturing	78	0.130	100	0.154
All Groups	1787	0.114	130	0.032

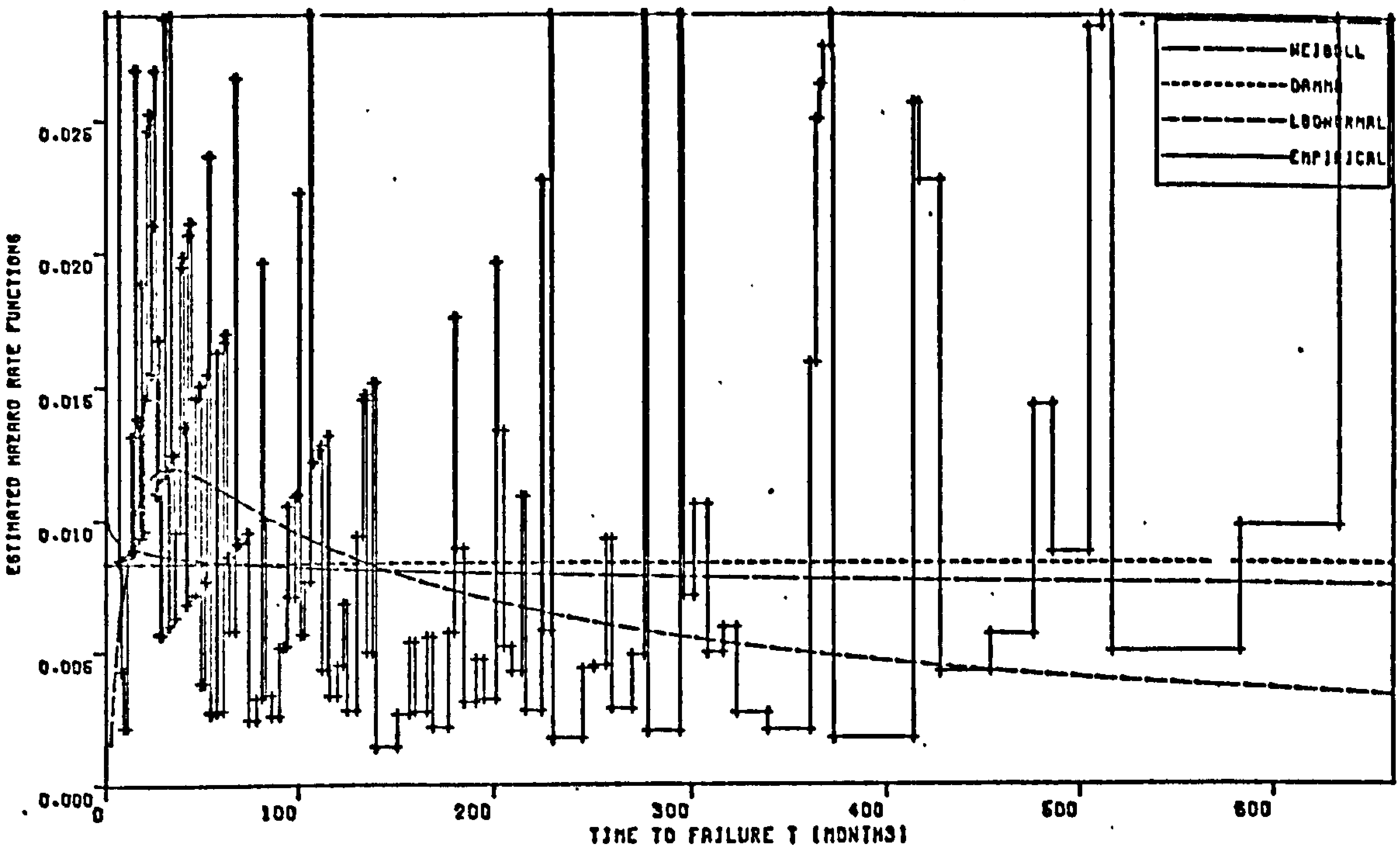


FIG 4.25 HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

TIMBER, FURNITURE ETC.,

	SHAPE	SCALE
LOG-NORMAL	1.09	4.21
WEIBULL	0.96	117
GAMMA	0.80	149

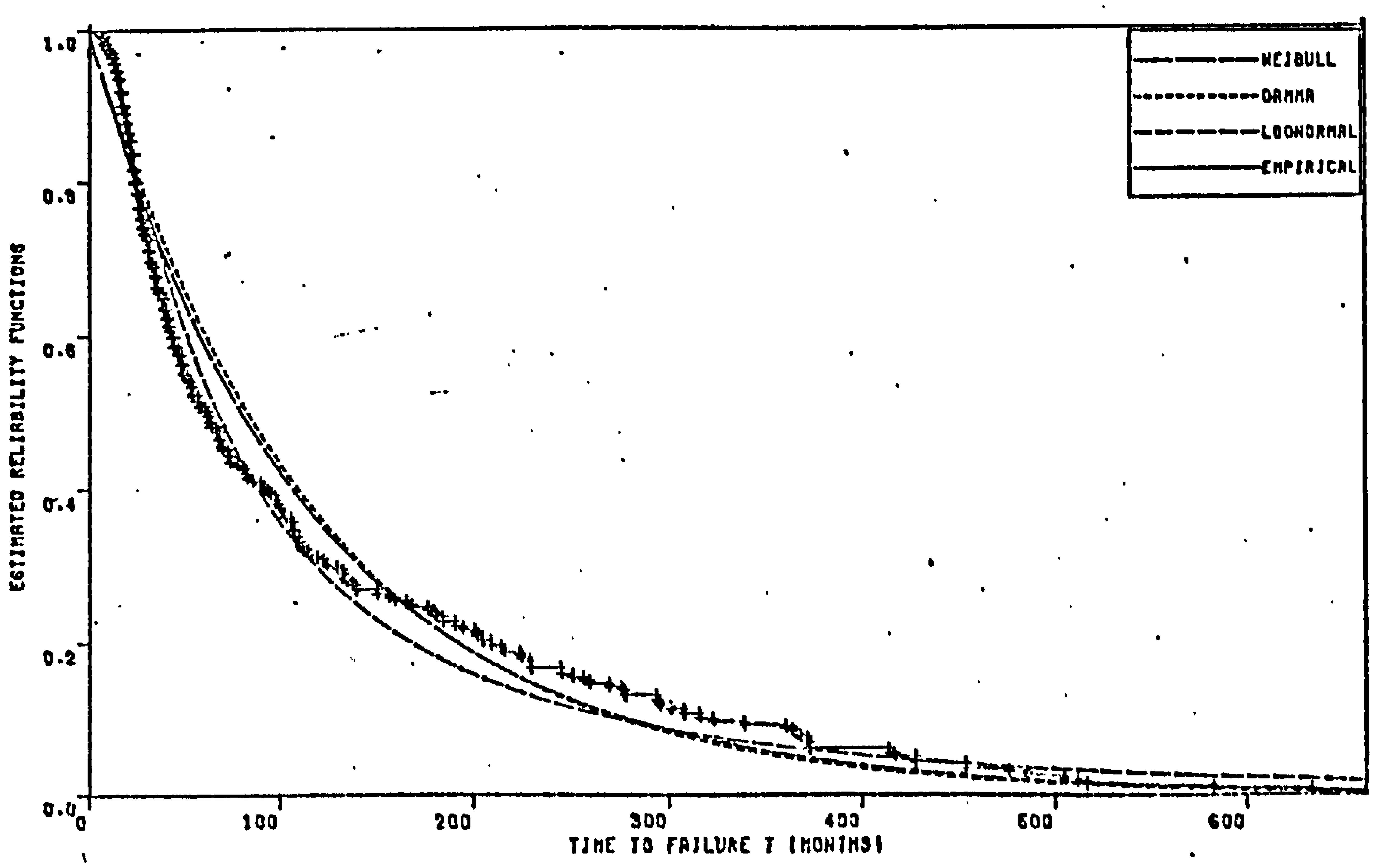


FIG 4.26 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

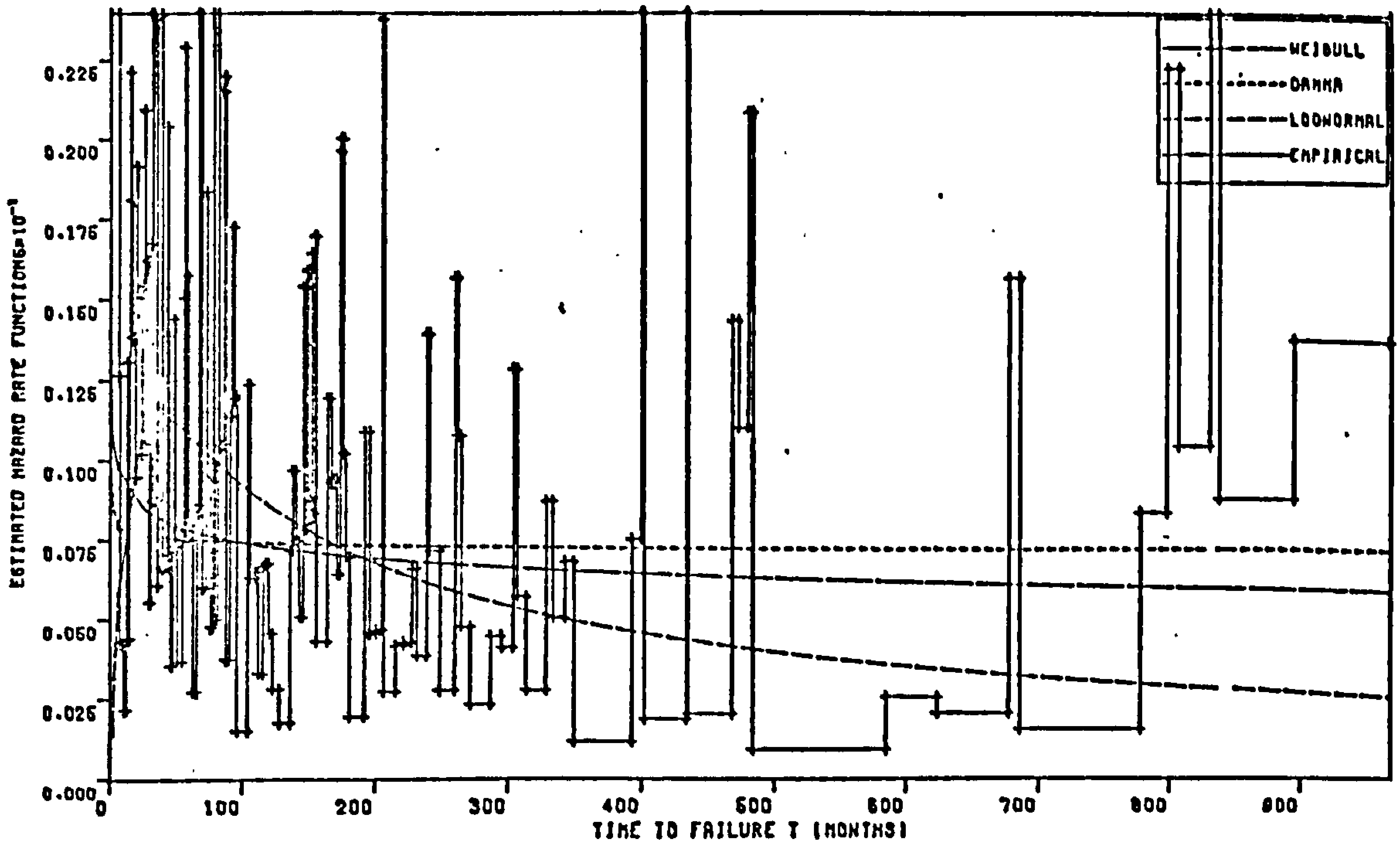


FIG 4.27 HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

PAPER, PRINTING AND PUBLISHING

	SHAPE	SCALE
LOG-NORMAL	1.09	4.25
WEIBULL	0.89	123
GAMMA	0.56	235

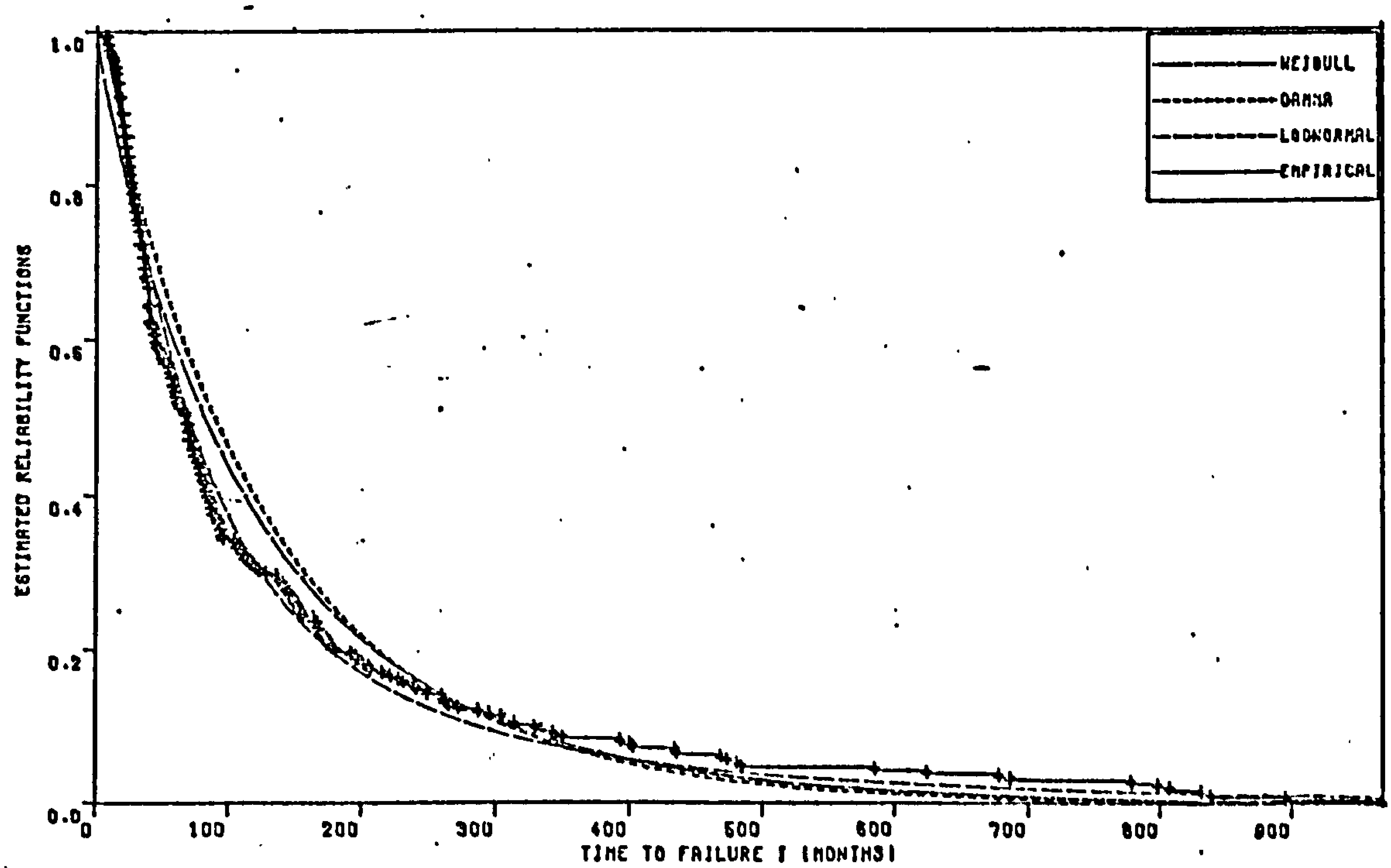


FIG4.28 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

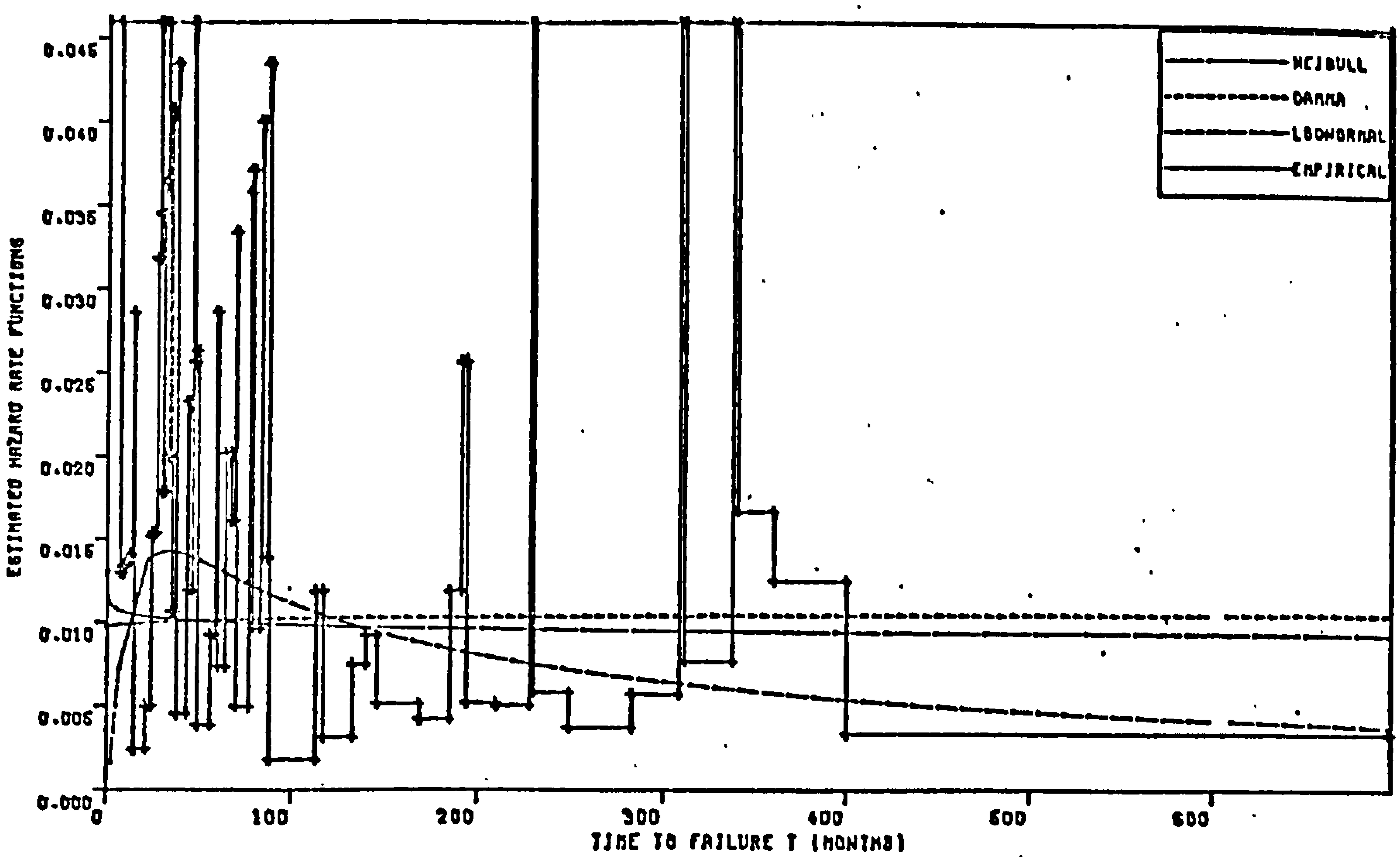


FIG 4.29 HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

OTHER MANUFACTURING INDUSTRIES

	SHAPE	SCALE
LOG-NORMAL	1.04	4.05
WEIBULL	0.97	98
GAMMA	0.70	141

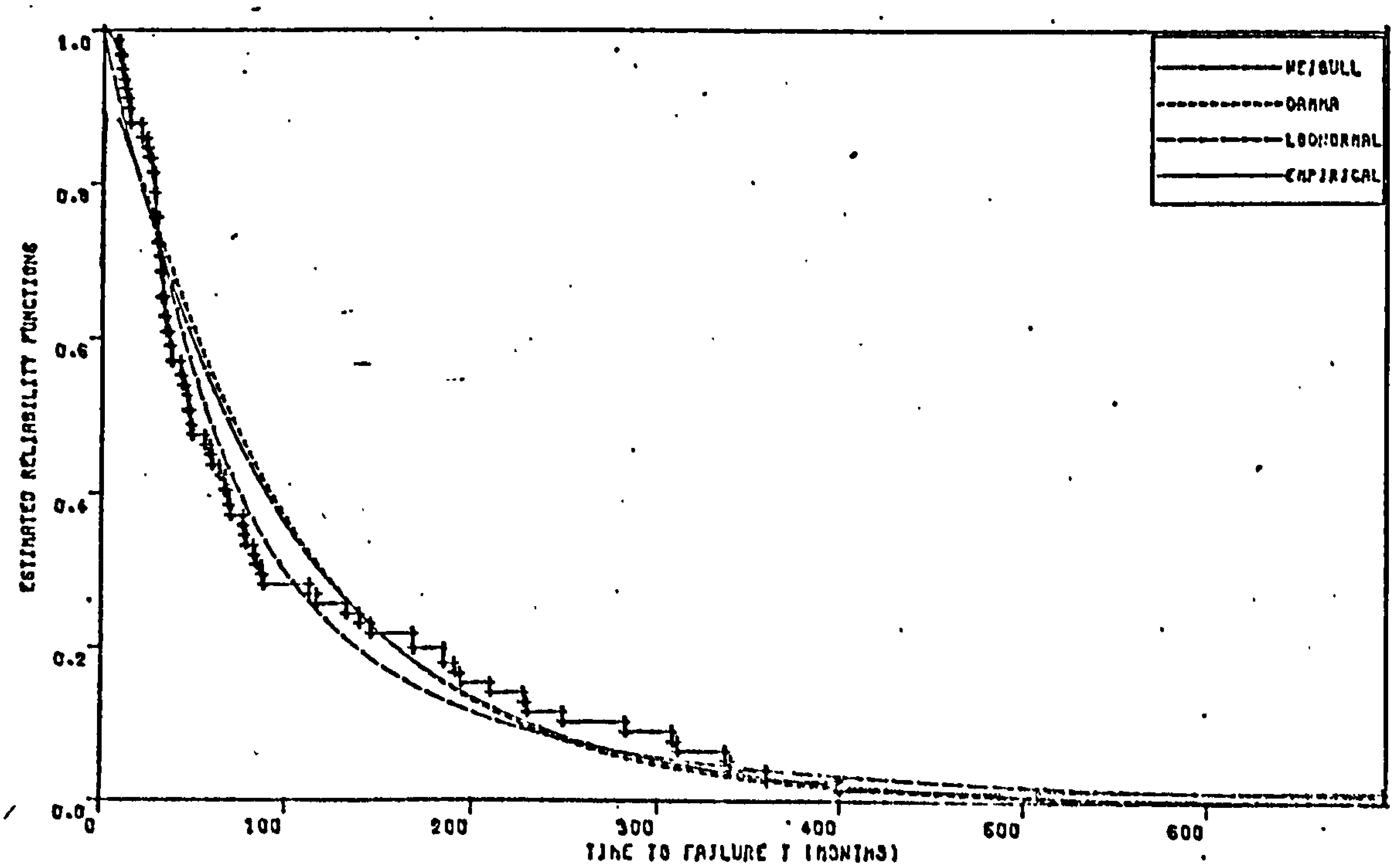


FIG4.30 RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

Table 4.5 gives the Mixed Weibull distribution parameters, K.S. test statistics, D-Max and the corresponding critical values at 5% confidence level for each group. As can be seen from this Table, the ratio of the late to the early scale parameters vary between 4 to 5 and the corresponding proportion parameters has a value of 50%, which seems to suggest that almost half of the companies are susceptible to the early failures which is about one-fourth of the characteristic life of the rest of the 50% of the companies examined. This, however, does not appear to be inconsistent with the sample cumulative distribution plot for all groups shown in Fig. 4.31 where about 50% of the companies fail before five years. Figs. 4.32 to 4.33 give the Bayesian probabilities of early failure with age for total manufacturing companies, paper, printing and publishing group. Figs. 4.34 to 4.49 show the reliability functions for fitted mixed-Weibull distribution. The hazard rate plots are also given in the same figures.

Because of the increased number of parameters in this model, one can observe a close fit to the sample reliability function. The probability of survival of the company can be directly read from these curves.

The conclusions regarding distributions examined are:

1. Weibull distribution adequately represents failure behaviour of companies examined, if and when the following assumptions are justified:

   a) the instantaneous hazard rate (conditional probability of failure of an existing company has a monotonic increasing or decreasing nature.

   b) if there is not any non-zero instantaneous hazard rate limit.

2. Log-normal distribution explains adequately the company failure data and its instantaneous hazard rate characteristic provides physical meaning with regard to the incipient failure of the companies observed. The practical interpretation of the decreasing instantaneous hazard rate is that a company progressively improves its chances of survival with

TABLE 4.5 Mixed Weibull Parameters of Company Failure Data - Manufacturing Industry

Industry Group	No. of Sample	PROPORTION		Early Failure		Late Failure		D-Max	Critical Values at 95% Significance
		Early Failure	Late Failure	Shape Param.	Scale Param.	Shape	Scale		
A	47	49.73	50.27	0.91	63.68	1.15	220.14	0.095	0.198
C	48	47.77	52.33	1.82	47.51	1.71	204.9	0.054	0.196
D	35	52.29	47.71	2.50	60	3.57	284	0.071	0.23
E	278	49.85	50.15	1.97	48.45	1.91	209.3	0.035	0.082
F	18	53.83	46.17	1.92	62.00	1.78	220	0.117	0.32
G	114	51.78	48.22	2.28	46.24	1.12	161	0.053	0.127
H	44	44.72	55.28	2.67	35.27	1.25	193.60	0.066	0.205
K	42	52.05	47.95	1.94	50.34	1.08	206.3	0.063	0.209
L	150	50.93	49.07	1.79	63.65	1.06	243.7	0.035	0.111
M	88	47.06	52.94	1.62	64.94	1.68	456.14	0.050	0.145
N	35	51.14	48.86	2.89	44	1.56	301.2	0.058	0.23
P	277	49.11	50.89	1.74	44.37	1.65	204.6	0.032	0.081
R	55	56.06	43.94	2.48	48.81	1.12	225	0.055	0.183
S	239	47.64	52.36	2.01	37.26	1.43	219.6	0.039	0.088
T	239	50.16	49.84	1.80	48.39	1.09	229	0.043	0.088
U	78	51.80	48.20	1.99	40.32	1.24	180.9	0.064	0.154
All	1787	49.36	50.64	o.85	47.56	1.21	230.7	0.023	0.032

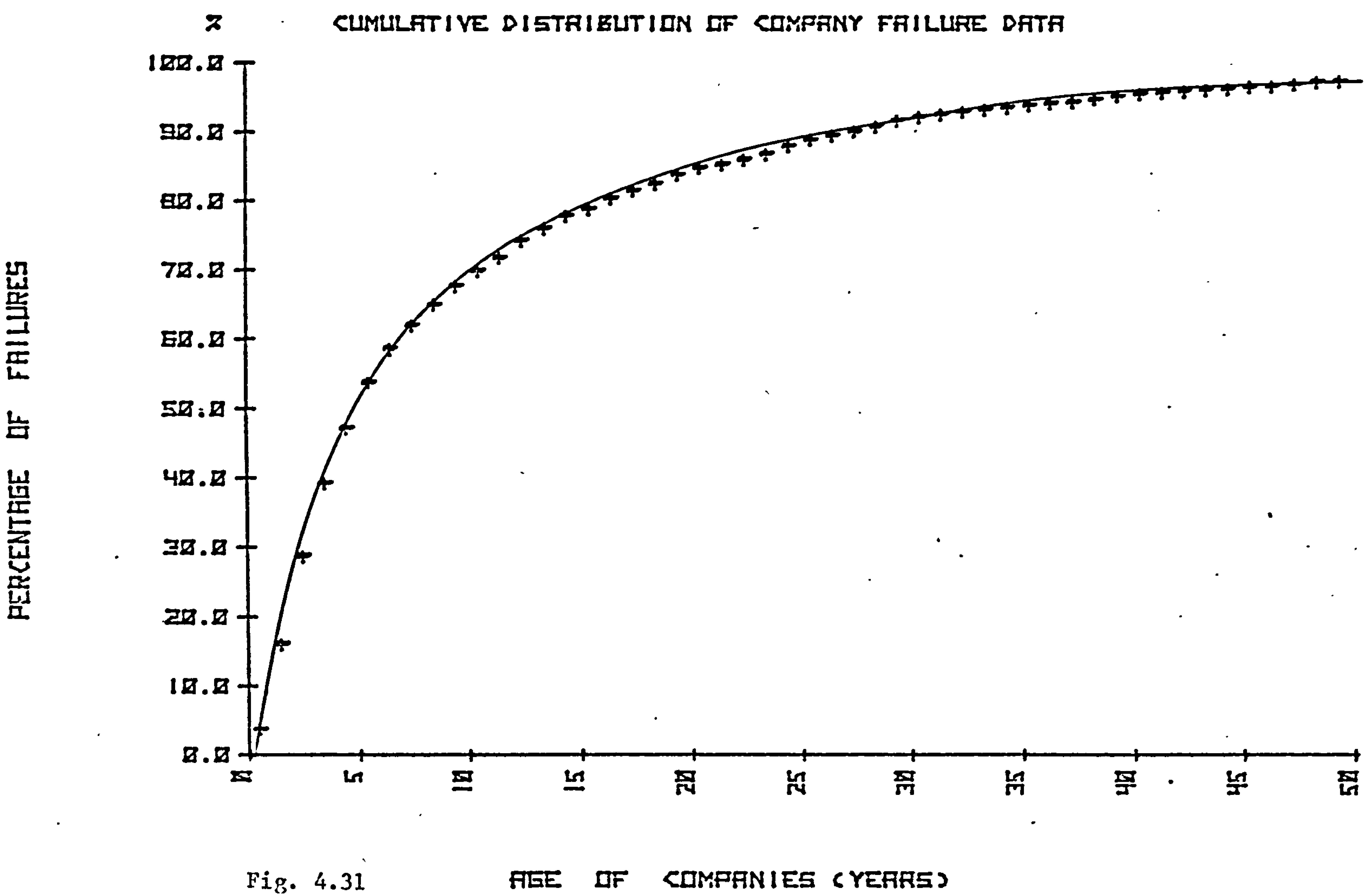

%
CUMULATIVE DISTRIBUTION OF COMPANY FAILURE DATA
PERCENTAGE OF FAILURES
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
5
10
15
20
25
30
35
40
45
50
AGE OF COMPANIES (YEARS)

Fig. 4.31

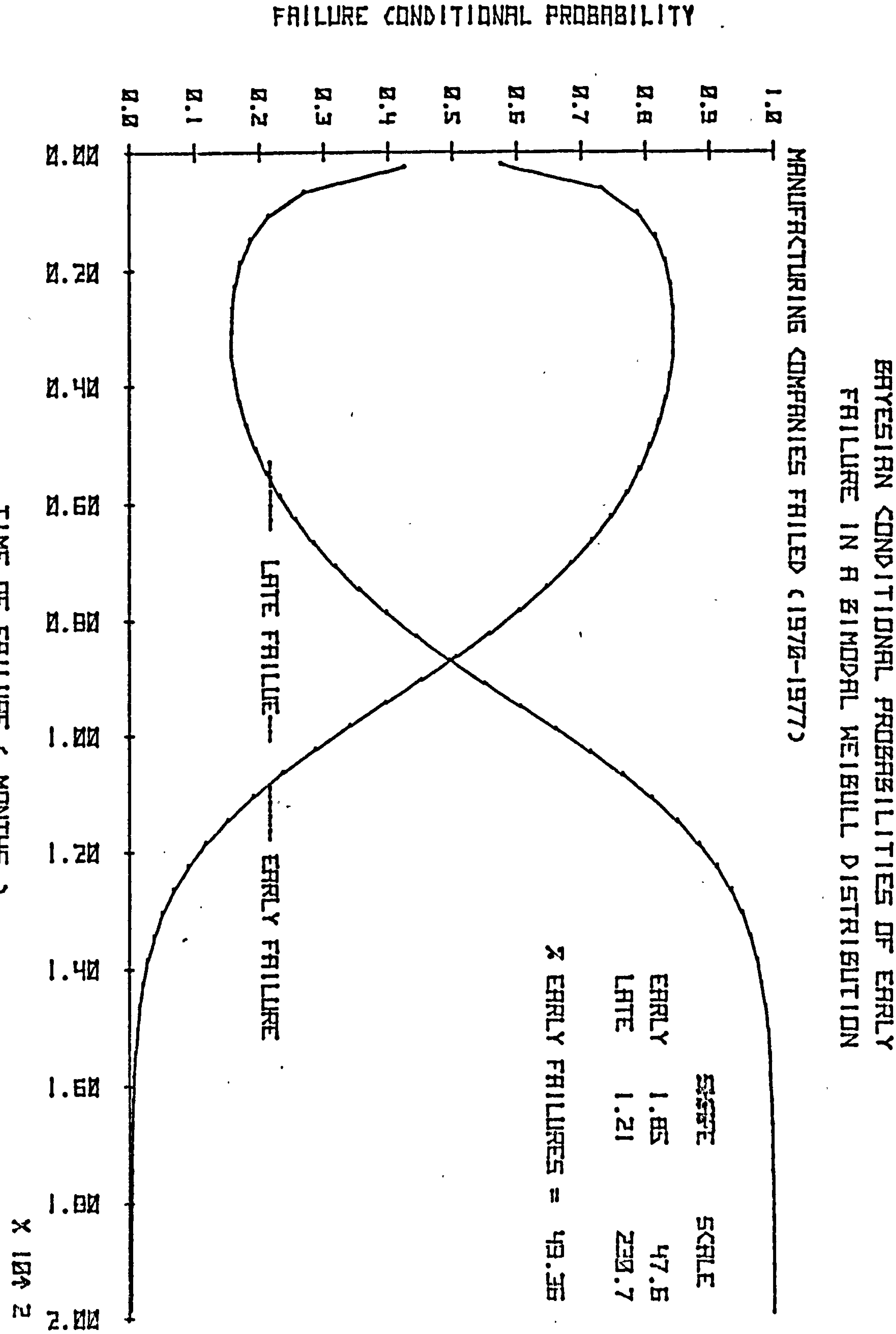

BAYESIAN CONDITIONAL PROBABILITIES OF EARLY
FAILURE IN A BIMODAL WEIBULL DISTRIBUTION
MANUFACTURING COMPANIES FAILED (1970-1977)
SHAPE SCALE
EARLY 1.65 47.6
LATE 1.21 220.7
% EARLY FAILURES = 49.35
FAILURE CONDITIONAL PROBABILITY
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
LATE FAILURE
EARLY FAILURE
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
X 10^ 2
TIME OF FAILURE (MONTHS)

Fig. 4.32

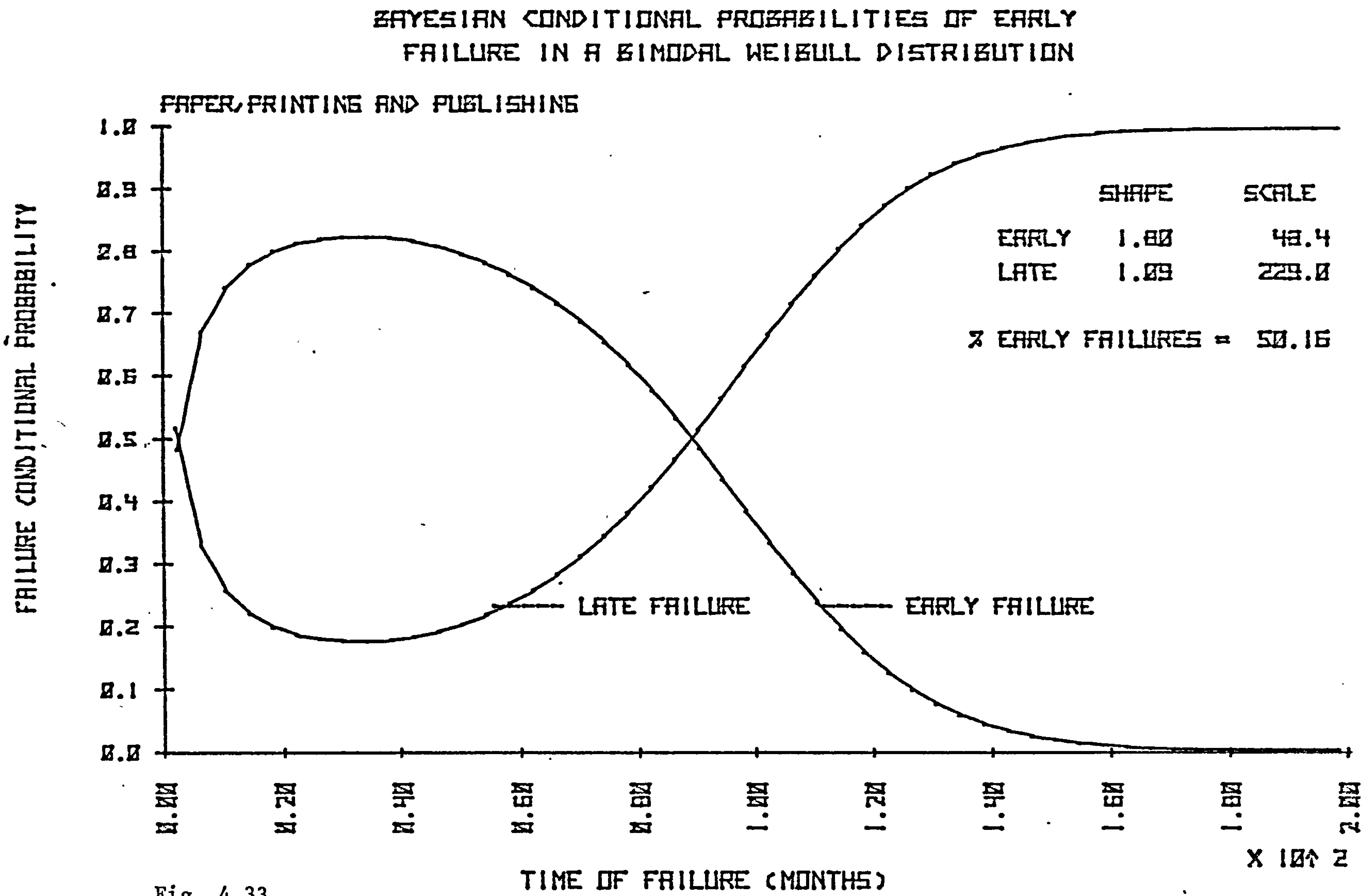

BAYESIAN CONDITIONAL PROBABILITIES OF EARLY
FAILURE IN A BIMODAL WEIBULL DISTRIBUTION
PAPER/PRINTING AND PUBLISHING
FAILURE CONDITIONAL PROBABILITY
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
SHAPE SCALE
EARLY 1.80 48.4
LATE 1.09 228.0
% EARLY FAILURES = 50.16
LATE FAILURE
EARLY FAILURE
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
X 10↑ 2
TIME OF FAILURE (MONTHS)

Fig. 4.33

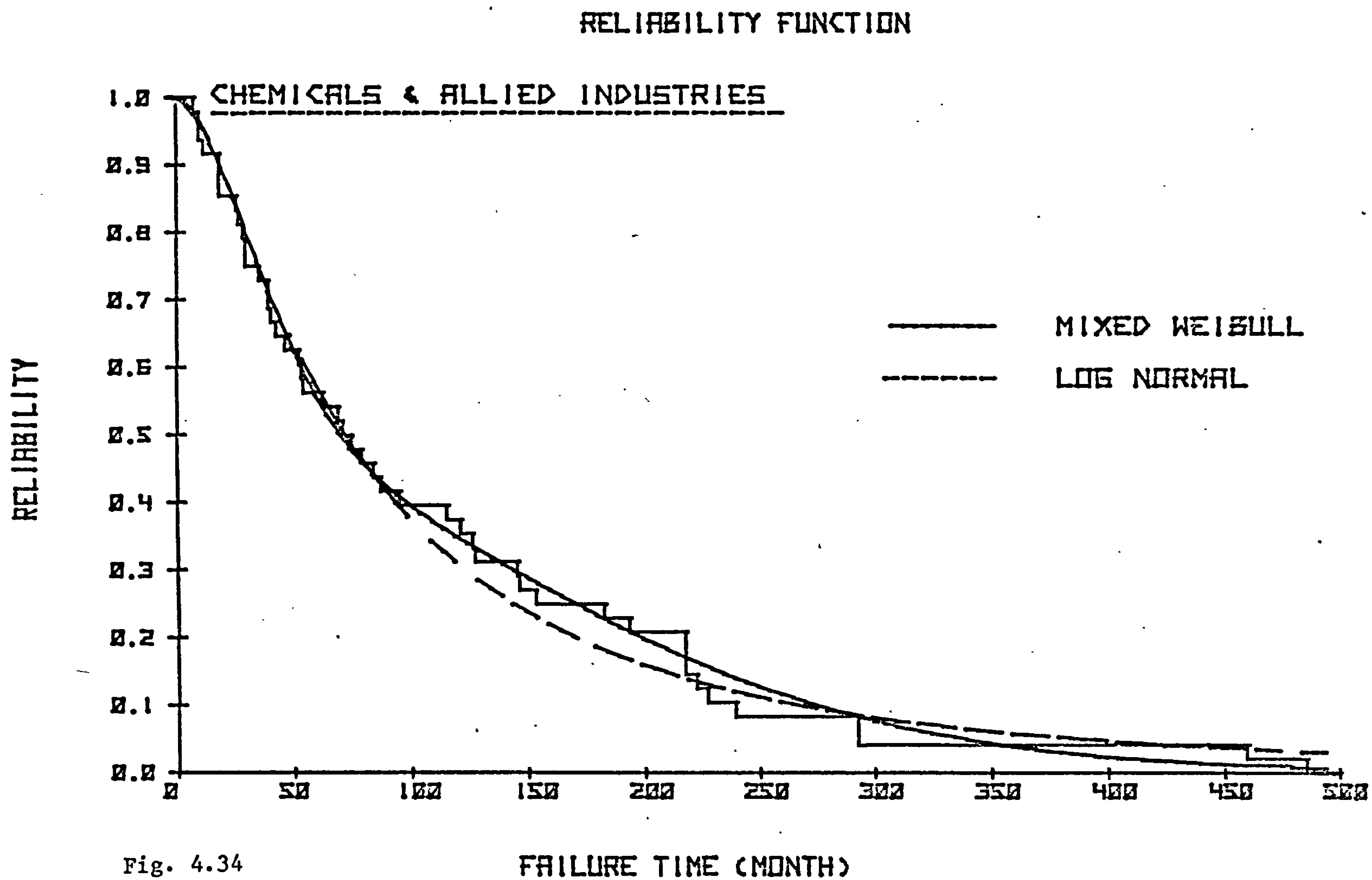

RELIABILITY FUNCTION
CHEMICALS & ALLIED INDUSTRIES
MIXED WEIBULL
LOG NORMAL
RELIABILITY
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
50
100
150
200
250
300
350
400
450
500
FAILURE TIME (MONTH)

Fig. 4.34

HAZARD RATE PLOT

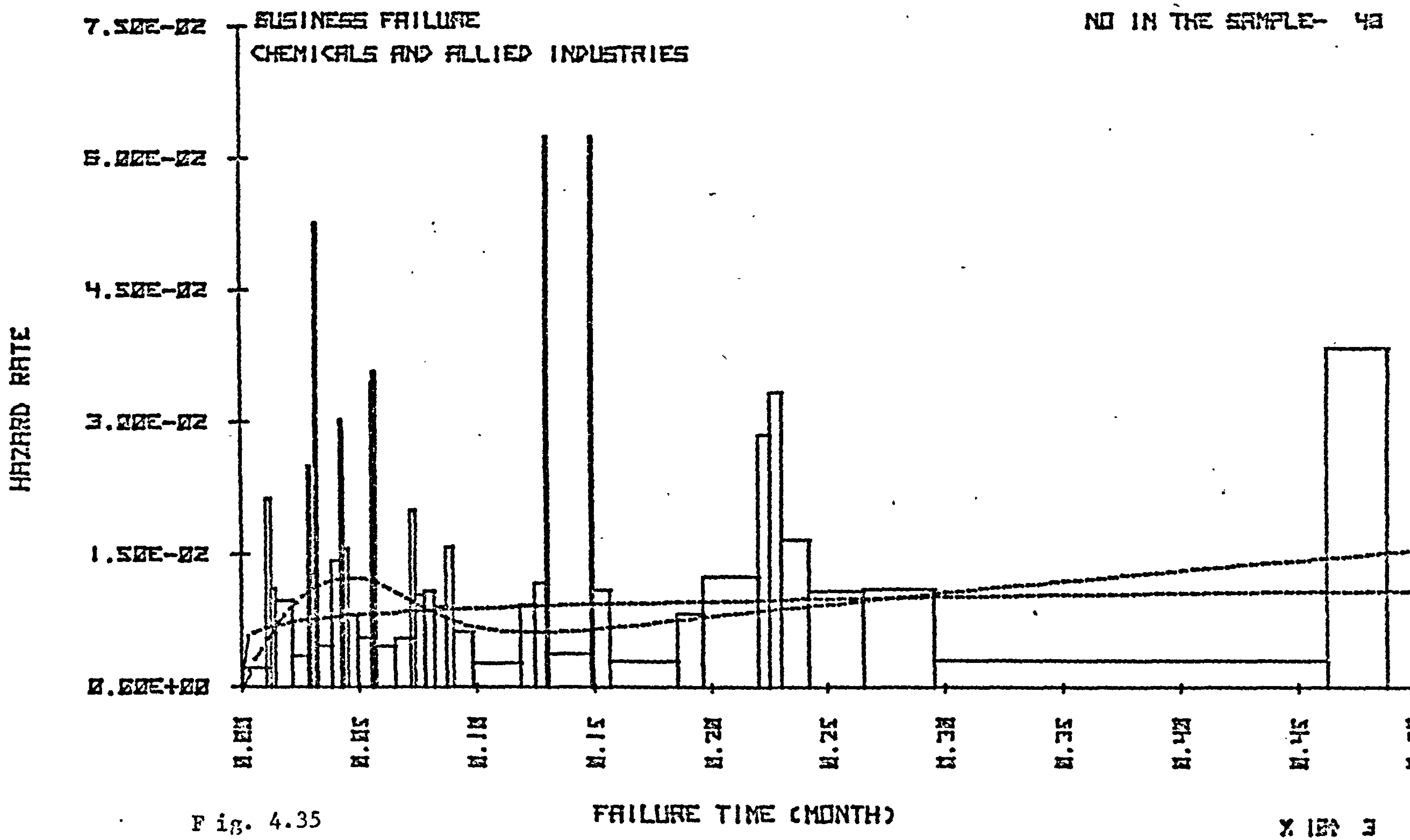


Fig. 4.35

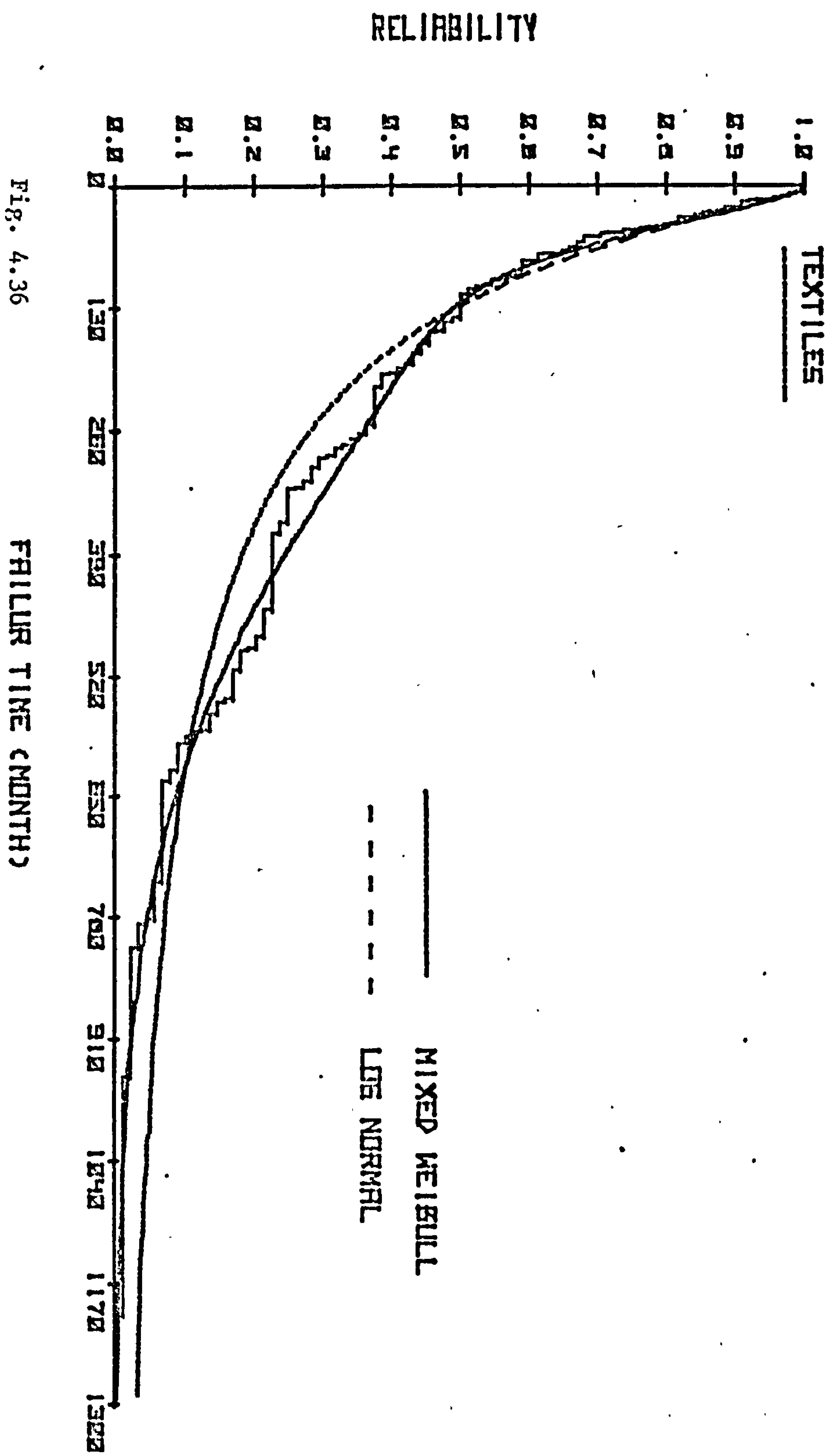

RELIABILITY FUNCTION
TEXTILES
RELIABILITY
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
MIXED WEIBULL
LOG NORMAL
0
130
260
390
520
650
780
910
1040
1170
1300
FAILUR TIME (MONTH)

Fig. 4.36

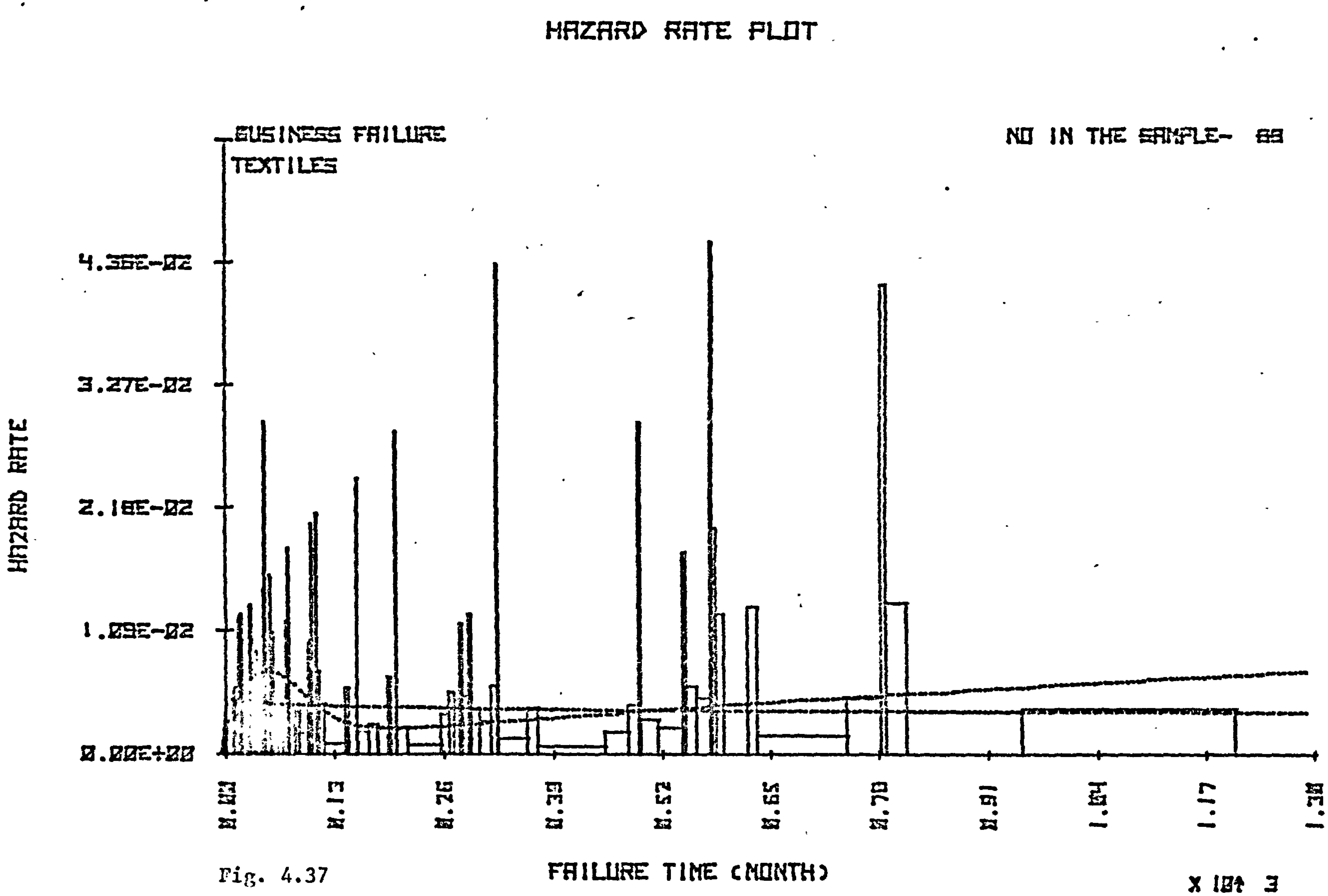

HAZARD RATE PLOT
BUSINESS FAILURE
TEXTILES
NO IN THE SAMPLE-
HAZARD RATE
4.36E-02
3.27E-02
2.18E-02
1.09E-02
0.00E+00
0.00
0.13
0.26
0.39
0.52
0.65
0.78
0.91
1.04
1.17
1.30
FAILURE TIME (MONTH)
X 10↑ 3

Fig. 4.37

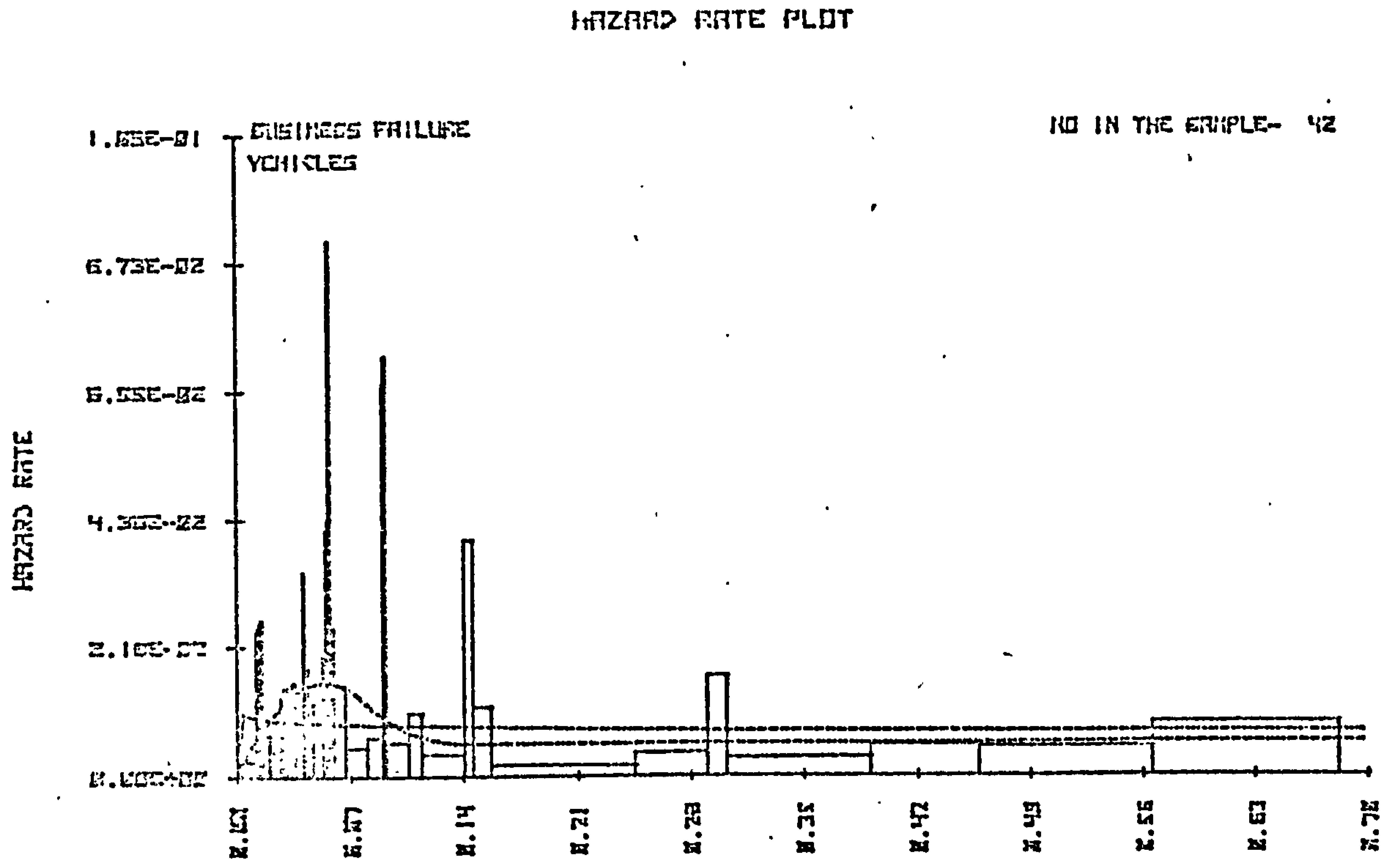


Fig. 4.38

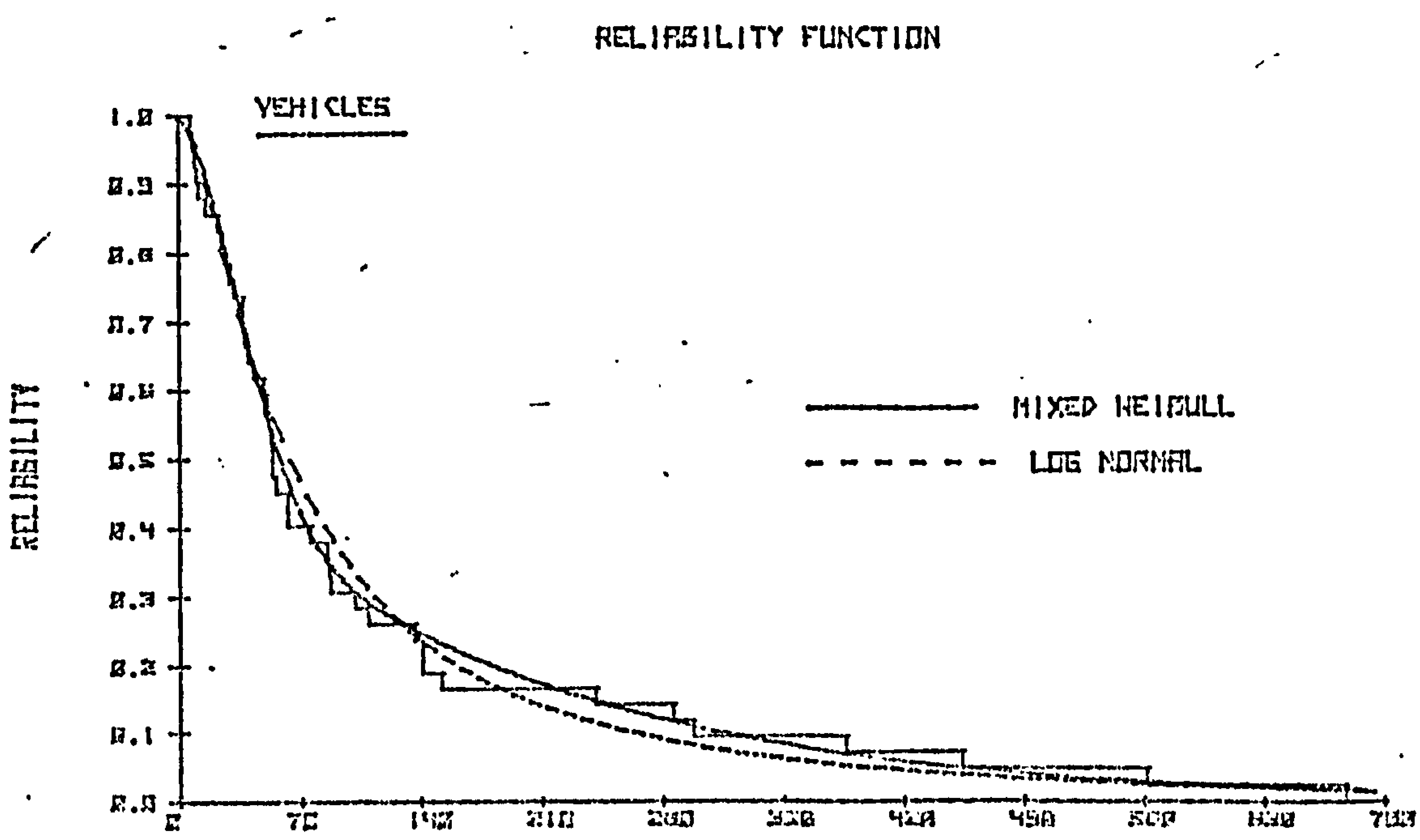


Fig. 4.39

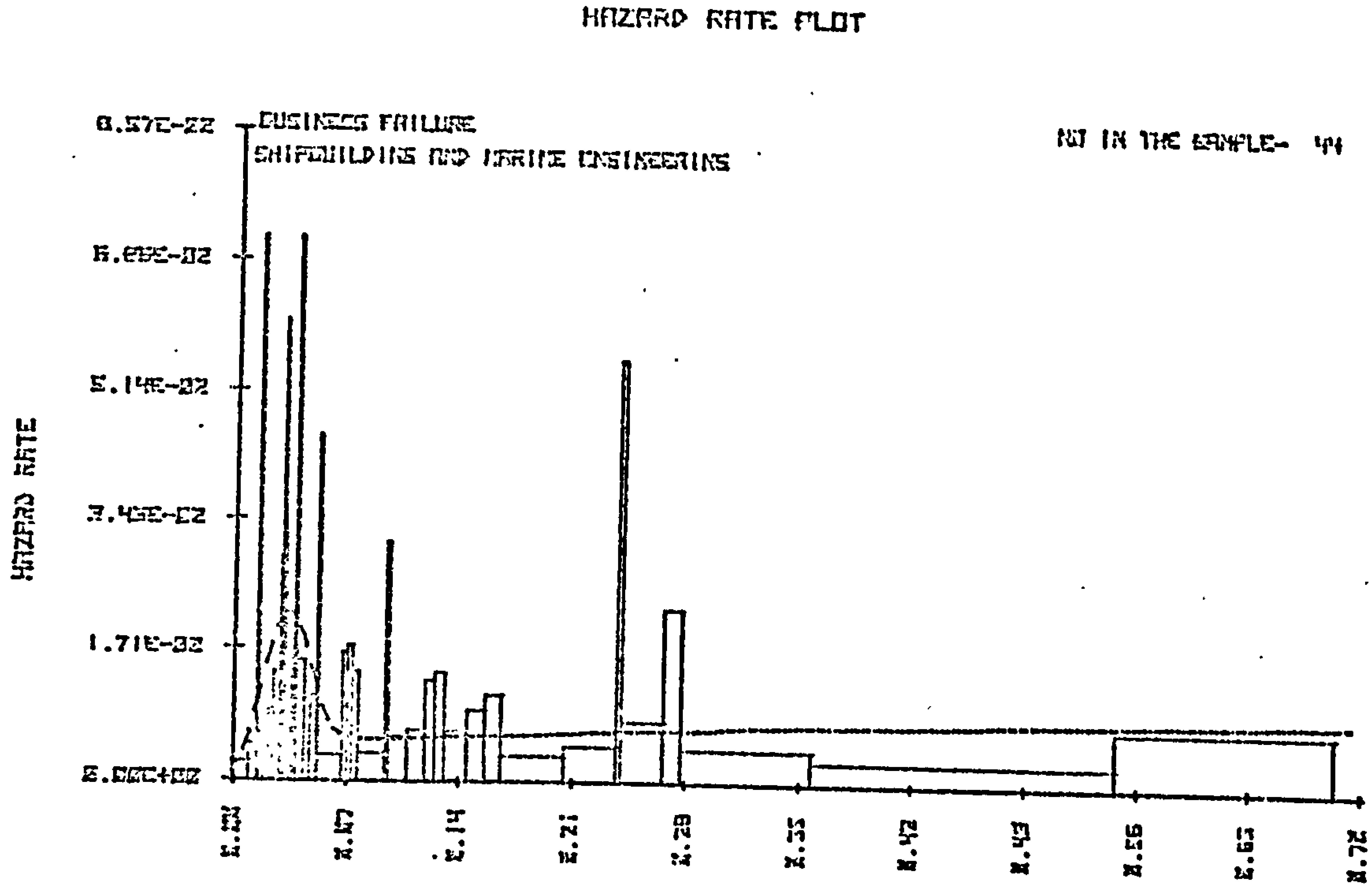


Fig. 4.40

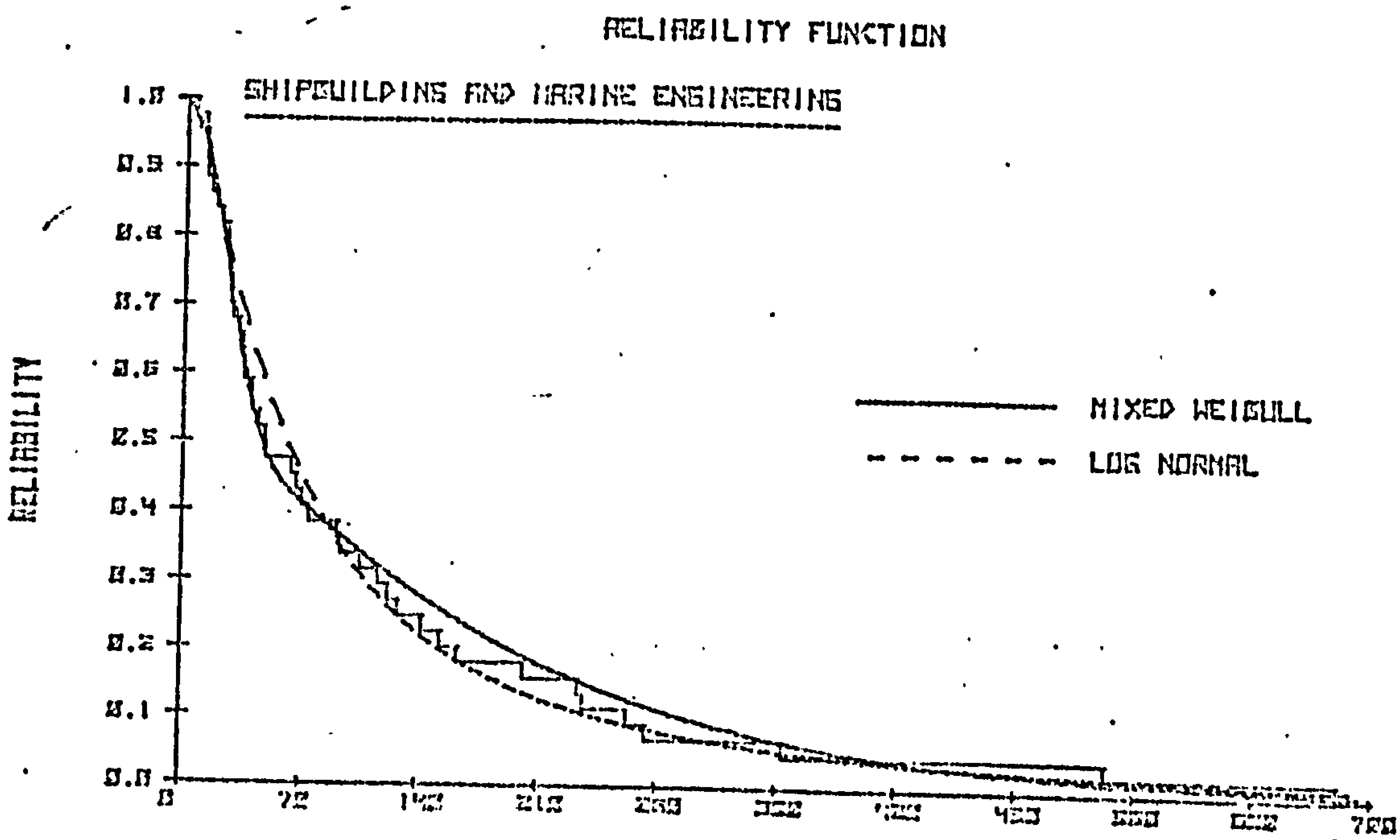


Fig. 4.41

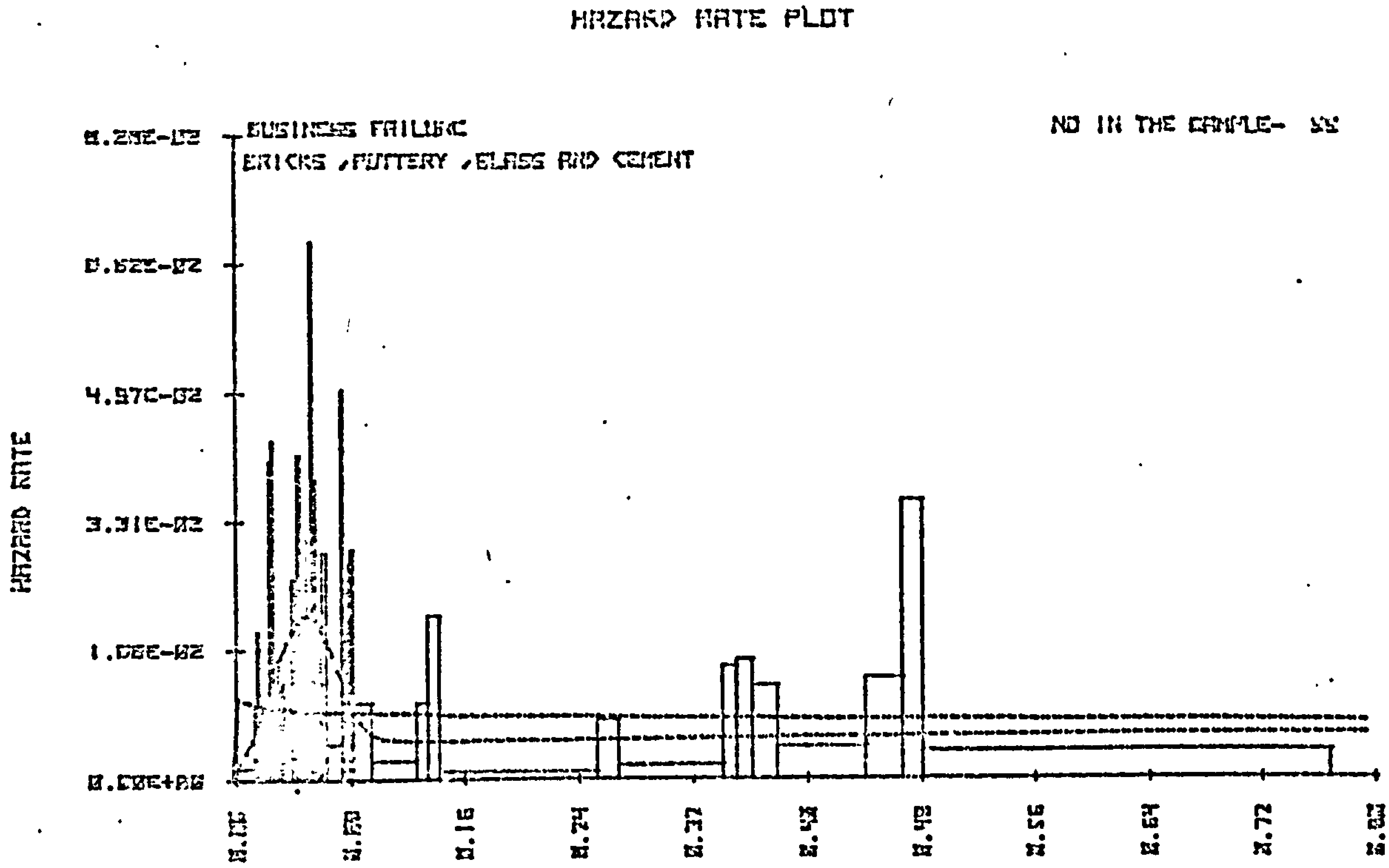


Fig. 4.42

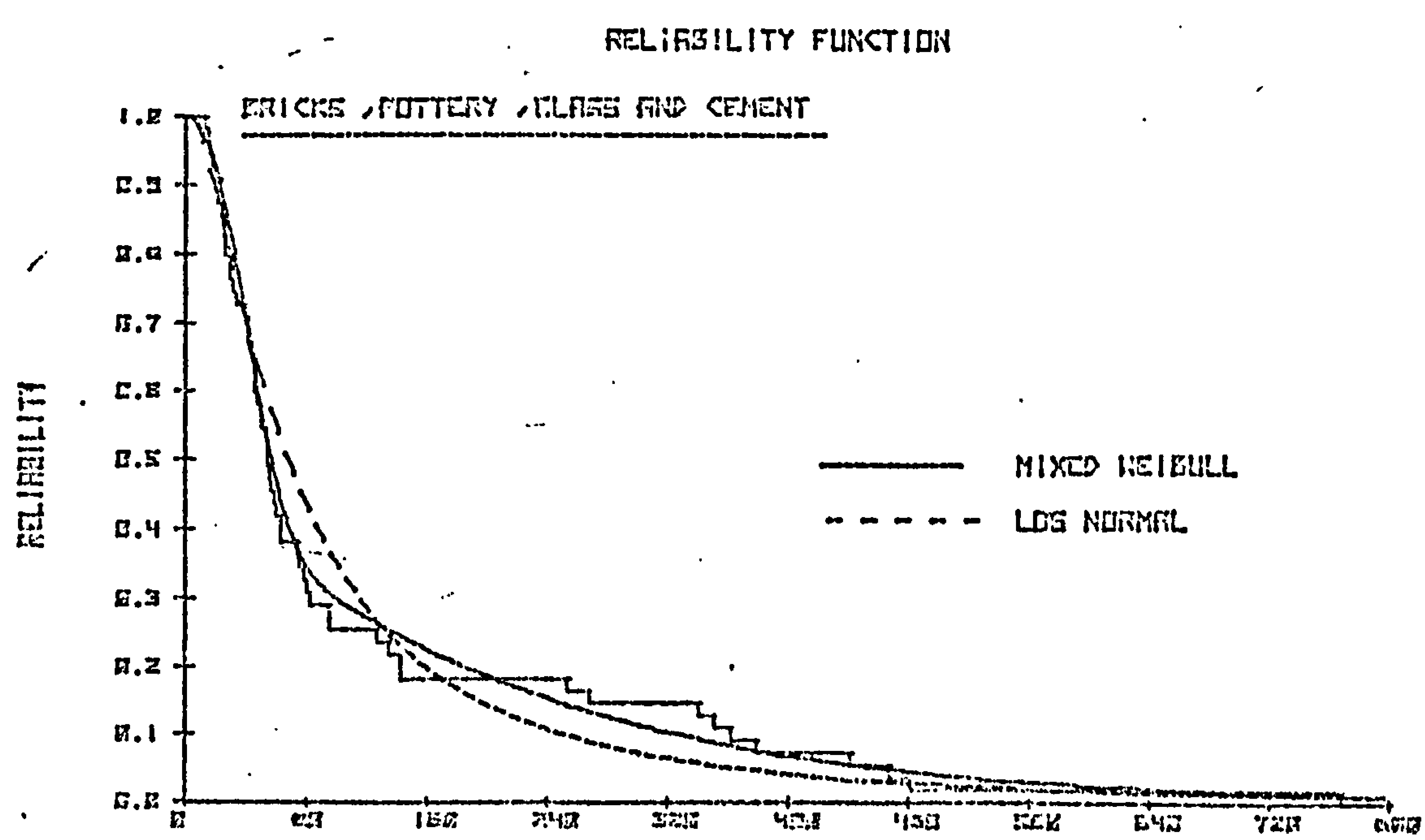


Fig. 4.43

HAZARD RATE PLOT

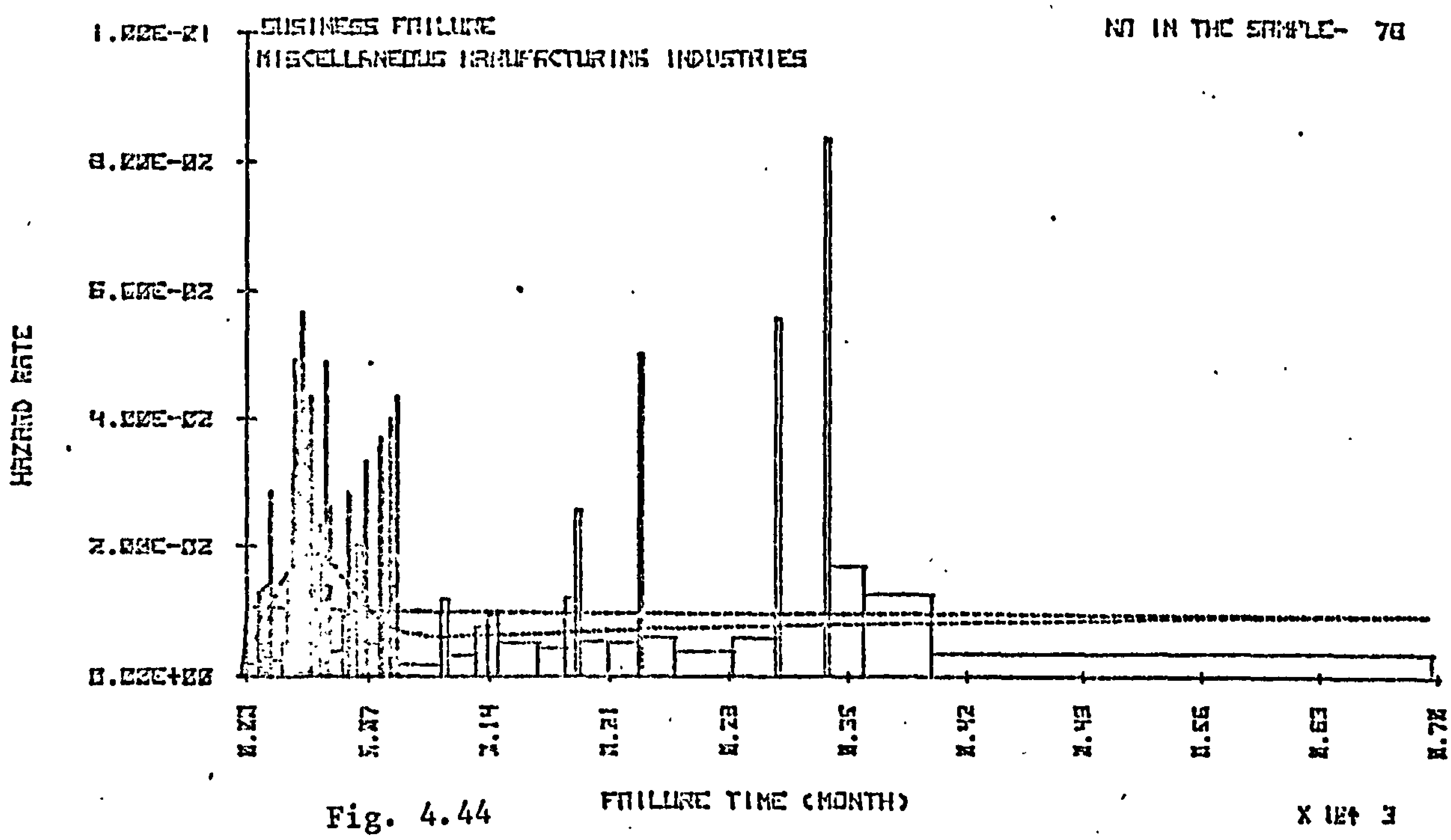


Fig. 4.44

RELIABILITY FUNCTION

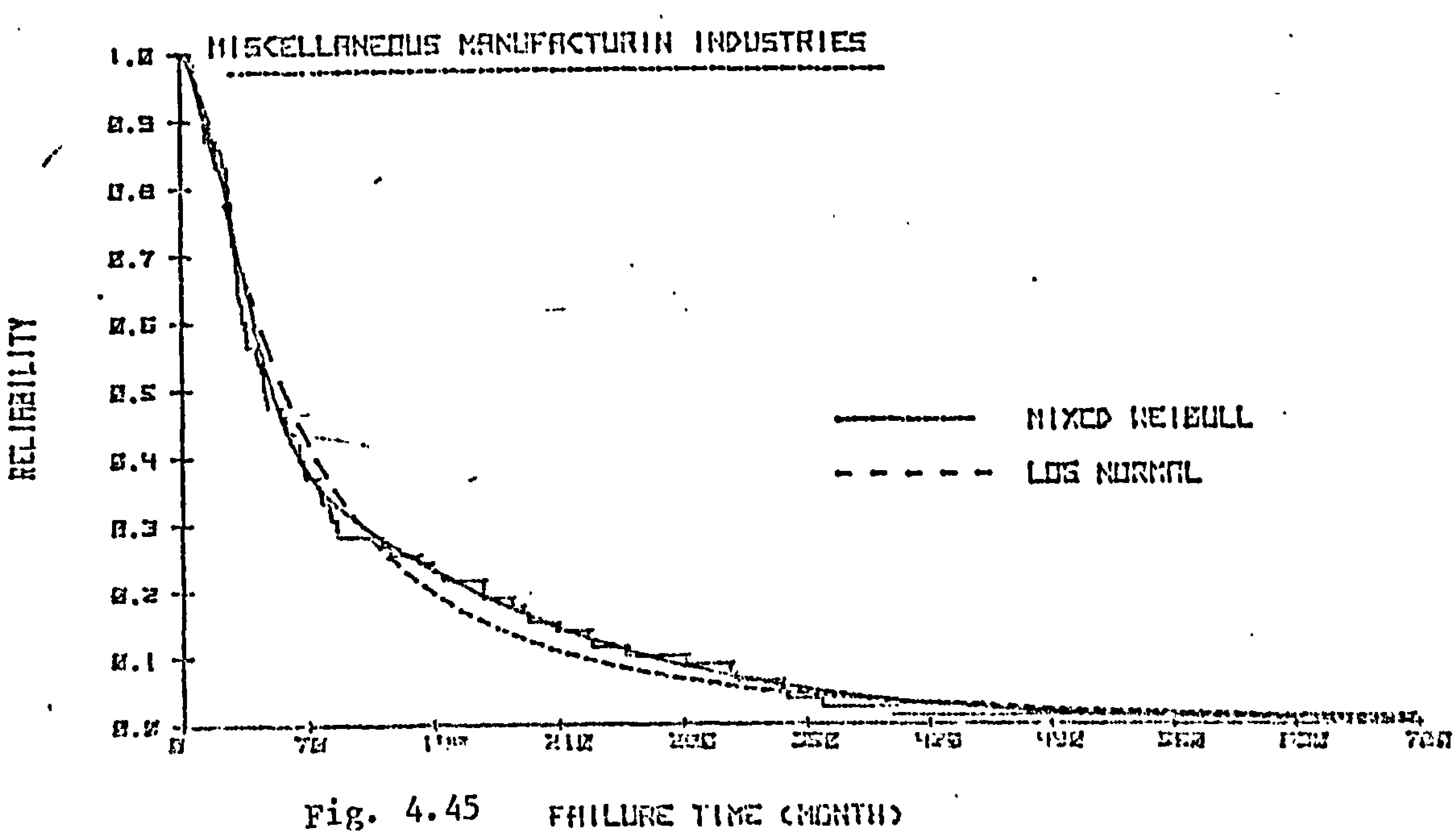


Fig. 4.45

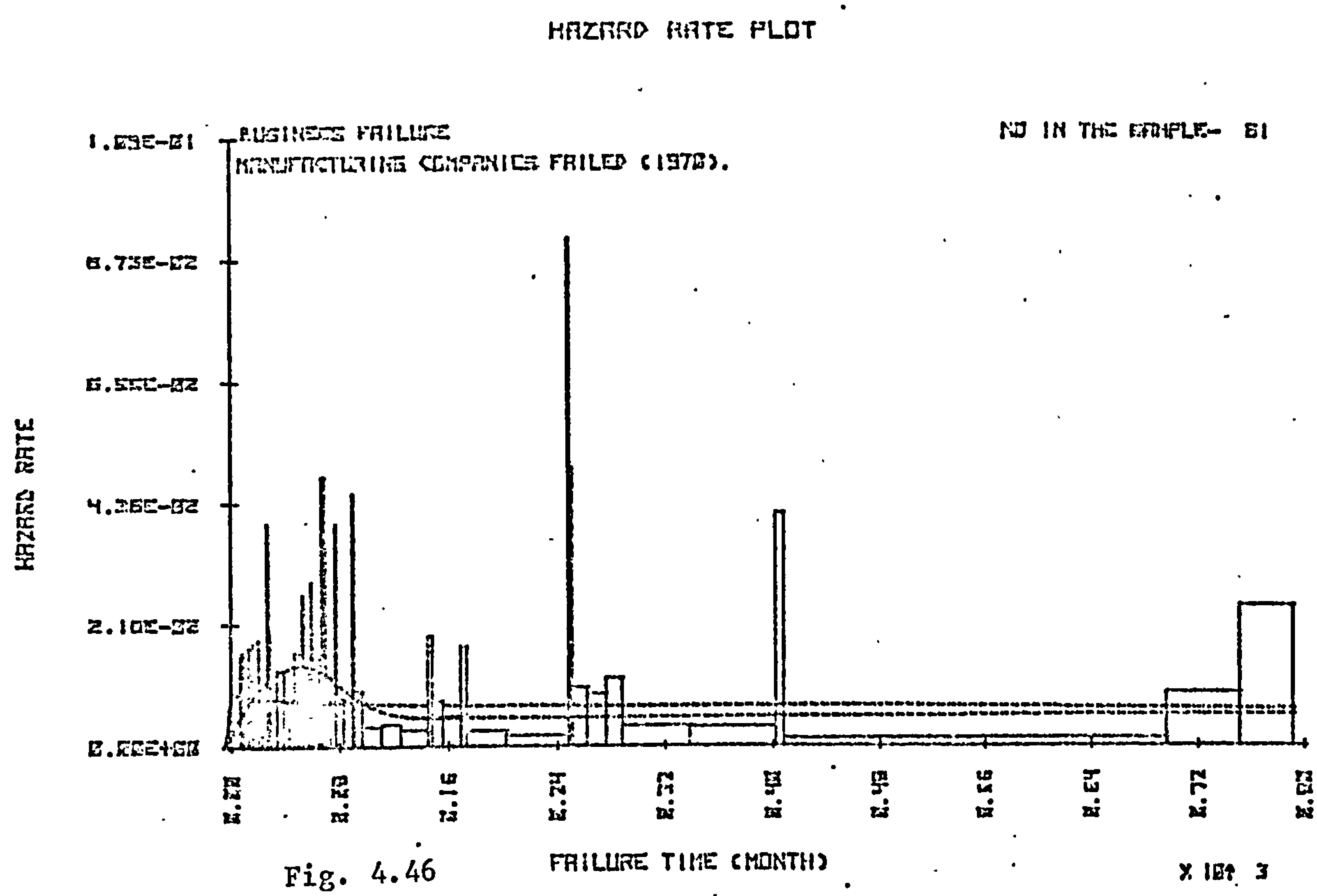


Fig. 4.46

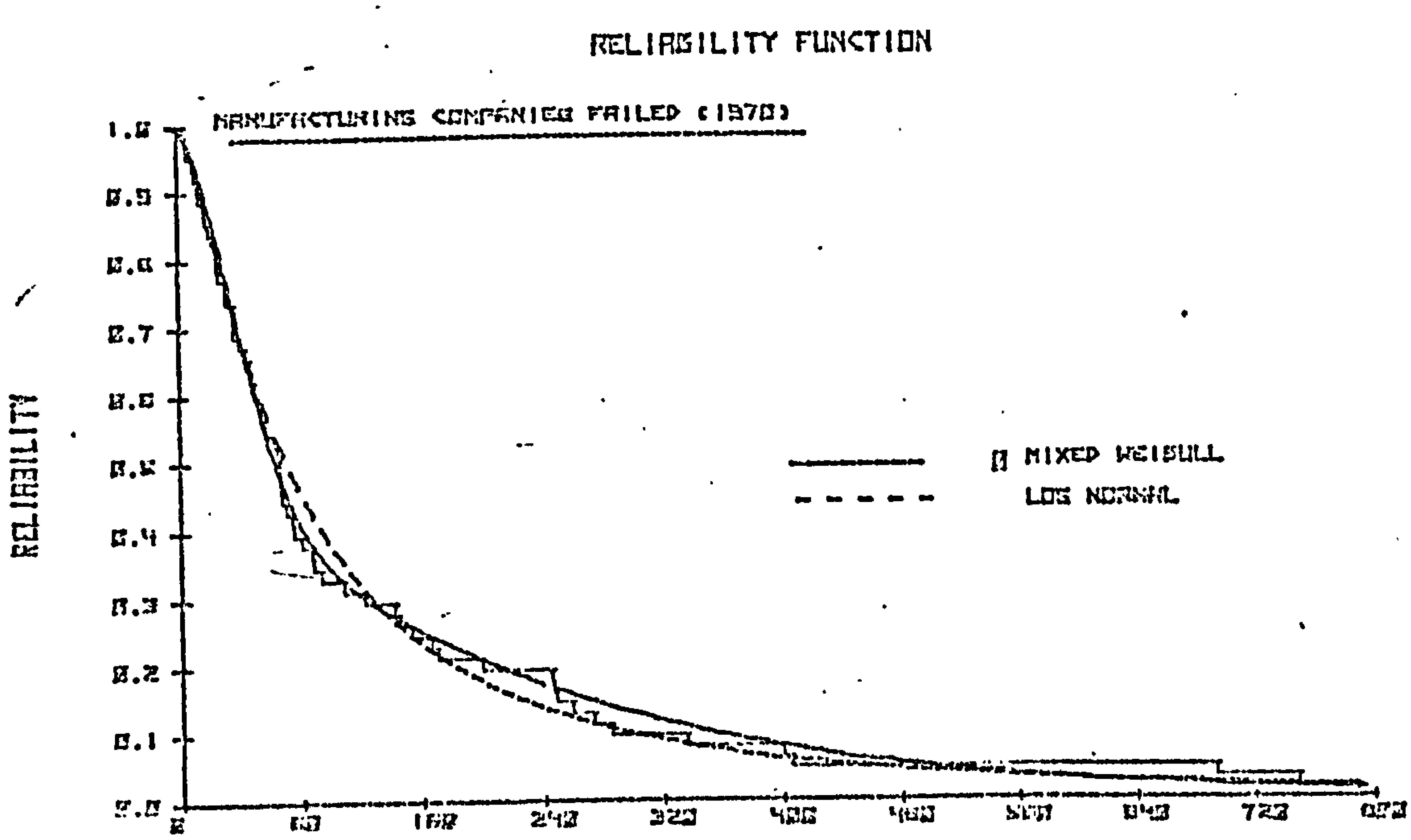


Fig. 4.47

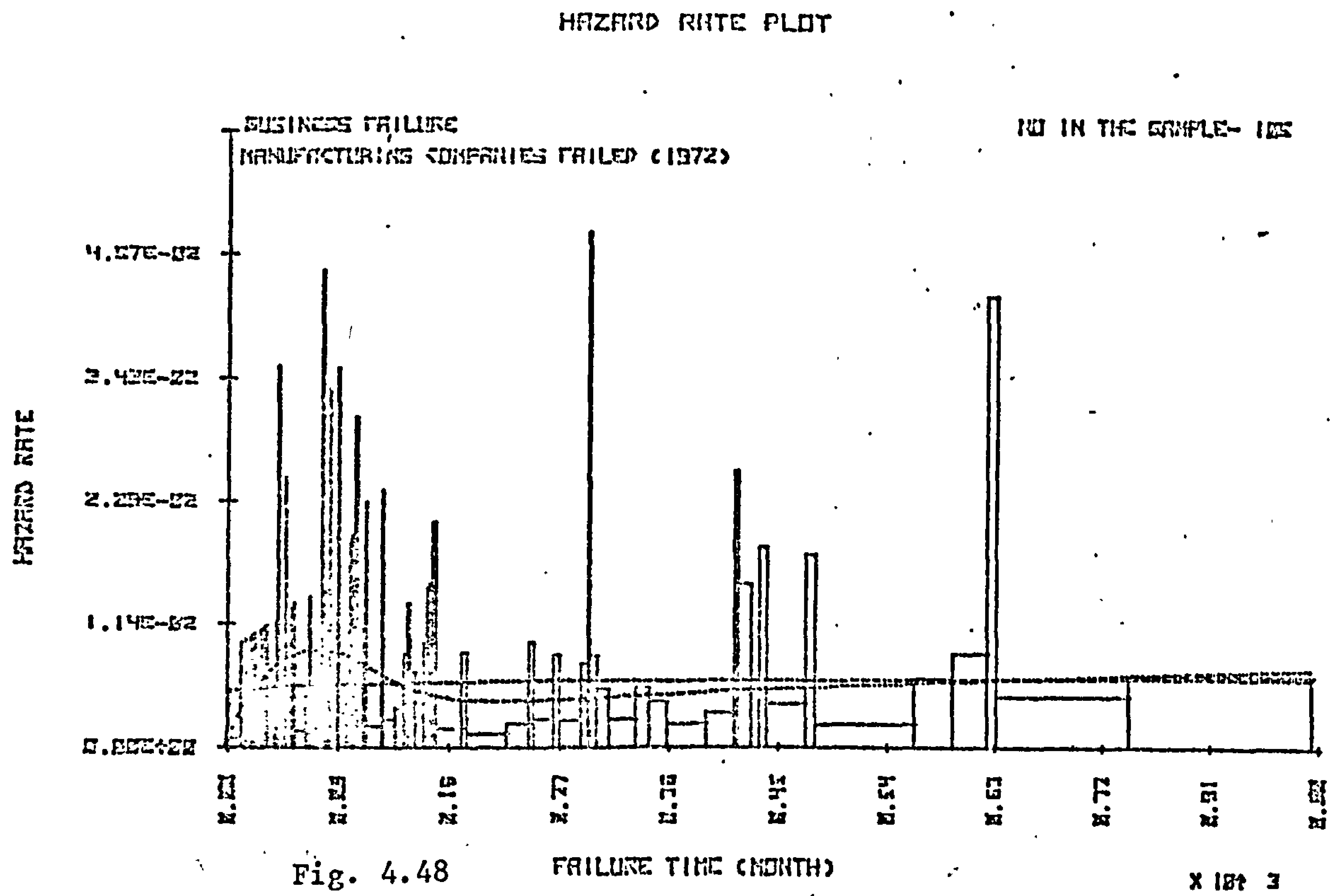


Fig. 4.48

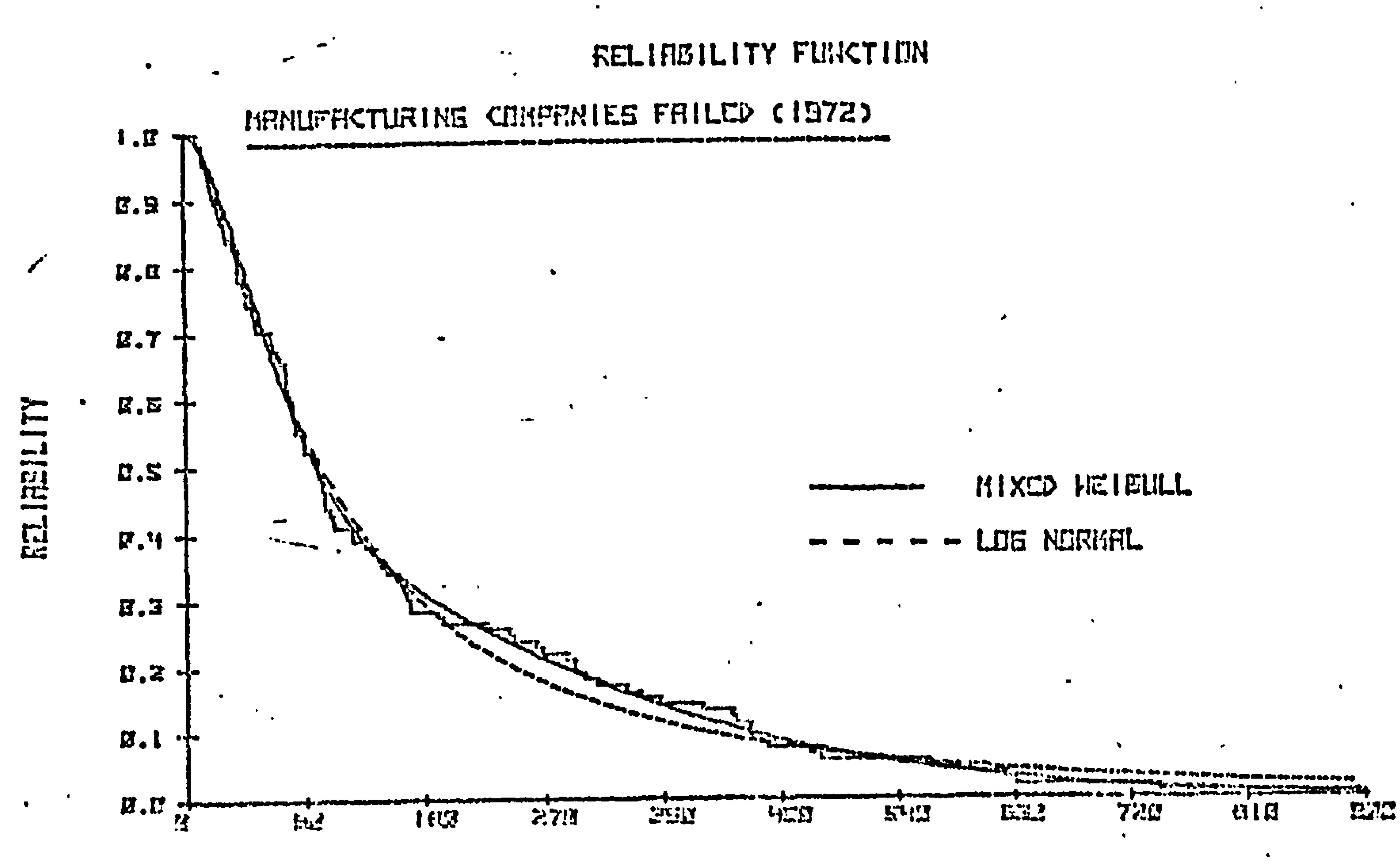


Fig. 4.49

experience after an initial period of infant mortality.

3. Gamma distribution, as mentioned earlier, has the characteristics closely related to the company failure data under the following assumptions:

a) the failure of the company is due to some accumulated causes and the nature of the causes itself being random.

b) the instantaneous hazard rate (conditional probability of failure) has a positive limit for the limiting value of age considered.

4. Exponential distribution describes company failure if the nature of failure is random. However, this does not explain the incipient failure observed in the company failure data.

5. Mixed Weibull distribution provides greater flexibility due to the increased number of parameters. It has the properties of both the limiting failure rate and the capability of representing incipient failures depending upon the values of its parameters. The application of the model is based on the following assumptions:

a) the companies have a dichotomous nature in which a proportion of companies are highly vulnerable to the external factors which cause the companies to fail prematurely, with the rest of the companies having a normal life.

b) both types of companies have the same failure behaviour characteristics (statistical distribution).

4.6.2 Analysis of company failure data according to year of failure

Tables 4.6 to 4.16 give the values of the parameters of the distributions used for individual year of failure (1970-1977). It can be observed from the Tables that in the year 1974 the mean life of companies studied indicates a relatively low age as compared with companies failed as a whole and other years. This reflects the general state of the national

TABLE 4.6 Distribution Parameters of Company Failure Data - Manufacturing Industry

			WEIBULL				LOG-NORMAL				GAMMA			
Year of Failure	No. of Sample	Critical Value at 5%	Shape Param.	Scale Param.	Mean mths.	D-Max	Shape Param.	Scale Param.	Mean	D-Max	Shape Param.	Scale Param.	Mean	D-Ma
1970	61	0.174	0.92	128	130	0.13	1.08	4.30	133	0.08	0.61	219.5	133.8	0.15
1971	90	0.143	0.86	138.6	148.6	0.10	1.19	4.33	155	0.05	0.57	262	150	0.13
1972	105	0.133	1.038	173	170.6	0.11	1.032	4.64	176.6	0.057	0.93	183.7	170	0.15
1973	141	0.115	0.92	111.8	116.5	0.12	1.06	4.17	113	0.085	0.58	200.8	117	0.15
1974	179	0.102	1.00	108	108	0.11	0.99	4.17	106.7	0.06	0.75	144	108	0.14
1975	307	0.078	0.93	119	123	0.12	1.07	4.23	122	0.07	0.66	185.5	123.6	0.14
1976	475	0.062	0.92	133	138	0.10	1.11	4.33	140.6	0.06	0.62	223	139	0.12
1977	429	0.066	0.96	121	122	0.10	1.06	4.25	124	0.05	0.69	176	123	0.12
1970-77	1787	0.032	0.937	125.6	130	0.092	1.08	4.28	130	0.04	0.66	198	130	0.14

TABLE 4.7 Mixed Weibull Parameters of Company Failure Data - Manufacturing Industry

Year of Failure	No. of Sample	PROPORTION		Early Failure		Late Failure		D-Max	Critical Values at 95% Significance
		Early	Late	Shape	Scale	Shape	Scale		
1970	61	50.92	49.08	1.95	53.46	1.11	232.8	0.045	0.174
1971	90	51.43	48.57	1.43	64.50	0.99	246.4	0.060	0.143
1972	105	51.42	48.58	1.77	75.36	1.43	308	0.052	0.133
1973	141	47.32	52.68	2.31	37	1.19	206	0.053	0.115
1974	179	50.35	49.65	2.01	47	1.23	188.3	0.054	0.102
1975	307	48.62	51.38	2.18	40.6	1.25	223	0.032	0.078
1976	475	48.44	51.56	1.84	47.13	1.21	246.6	0.027	0.062
1977	429	49.63	50.37	1.93	46.86	1.25	219.4	0.025	0.066
1970-77	1787	49.36	50.64	1.85	47.56	1.21	230.7	0.023	0.032

TABLE 4.8 Manufacturing Companies Failed in 1970

Distributions		D-Max	Parameters		Mean	Proportion of Failure	
			Shape	Scale		Early	Late
Weibull	Early	0.045	1.95	53		50.92	
	Late		1.11	233			49.08
Log-Normal		0.08	1.08	4.30	133		
Weibull		0.13	0.92	128	133		
Gamma		0.15	0.61	220	133		

Critical Value at 95% Significance Level = 0.174

No. in the Sample = 61

TABLE 4.9 Manufacturing Companies Failed in 1971

Weibull	Early	0.060	1.43	64	-	51.43	-
	Late		0.99	246			48.57
Log-Normal		0.05	1.19	433	155		
Weibull		0.10	0.86	139	149		
Gamma		0.13	0.57	262	150		

Critical Value at 95% Significance Level = 0.143

No. in the Sample = 90

TABLE 4.10 Manufacturing Companies Failed in 1972

Weibull	Early	0.052	1.77	75.36		51.42	
	Late		1.43	308			48.58
Log-Normal		0.057	1.03	4.64	177		
Weibull		0.11	1.03	173	171		
Gamma		0.15	0.93	184	170		

Critical Value at 95% Significance Level = 0.133

No. in the Sample = 105

economy in that particular year and that the newly formed companies were particularly vulnerable to the recession and the effect of the oil crisis. In general, the mean life gives an indication of macro-economic effects on individual companies. The hazard rate and reliability functions for each year are given in Figs. 4.50 to 4.67 . The interpretation of the plots depends on the validity of assumptions and the values of parameters shown in the Tables 4.6 to 4.16. One can infer from these values that the failed companies in England and Wales during the period 1970 to 1977 exhibited a common failure behaviour.

4.6.3 Analysis of company failure data for each group

The parameters of the distributions examined in this study are given for each group of companies in Tables 4.17 to 4.32. In most of the groups the Weibull characteristic life of companies appears to lie between 110 and 130 months (i.e. 9 to 11 years) with an almost random failure characteristic being exhibited in most cases (shape parameter ≃ 1). In particular, metal manufacture, metal goods, textiles, leather goods and fur indicate a comparatively longer life span than the rest of the companies. Considering the failure characteristics of the companies as a whole and disregarding the nature of individual industrial groups, the overall Weibull scale parameter of 125.6 months indicates that 63.3% of new-born companies fail before achieving an age of 10 years.

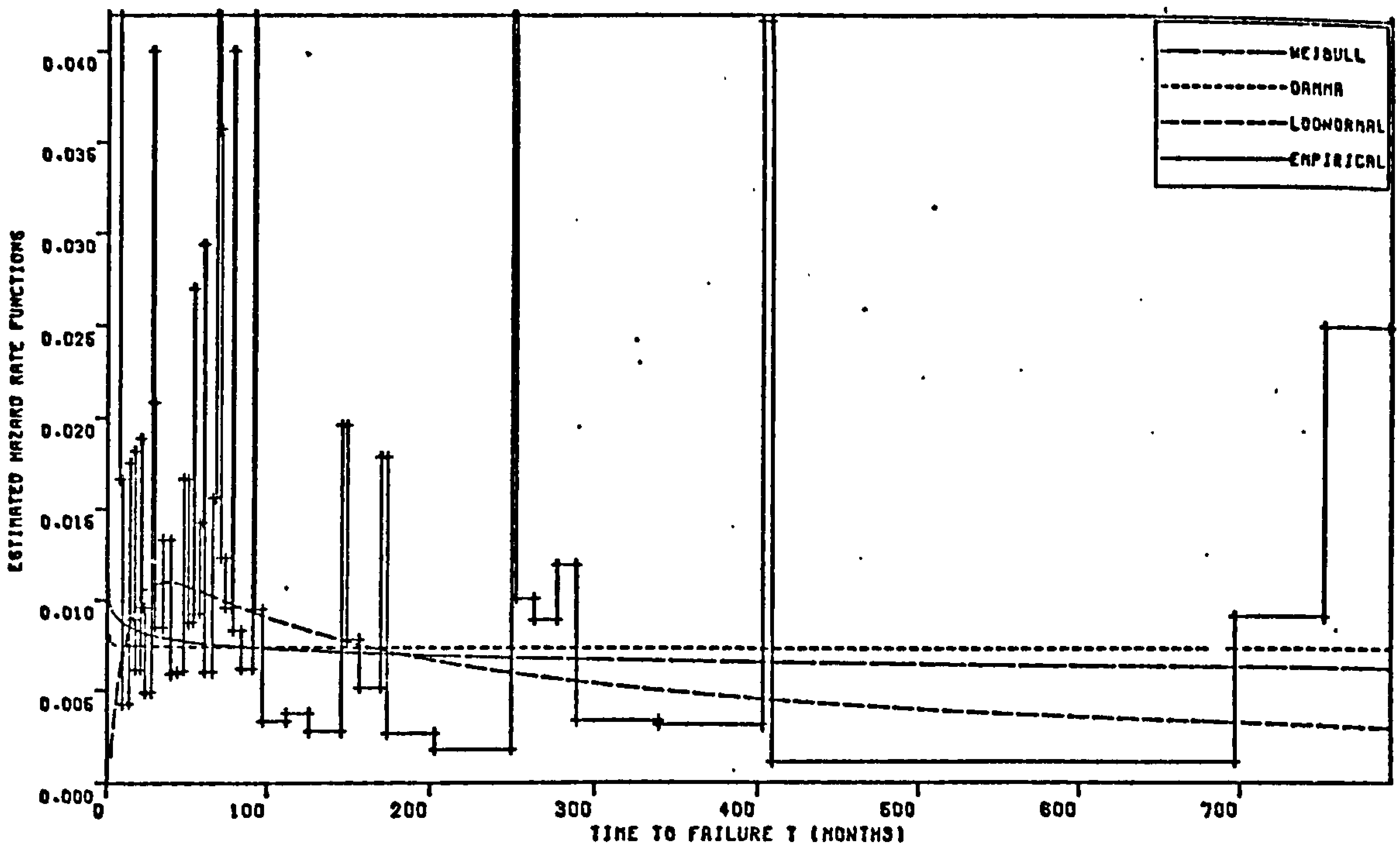


Fig. 4.50 FIG : HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1970

	SHAPE	SCALE
LOG-NORMAL	1.08	4.30
WEIBULL	0.92	128
GAMMA	0.61	220

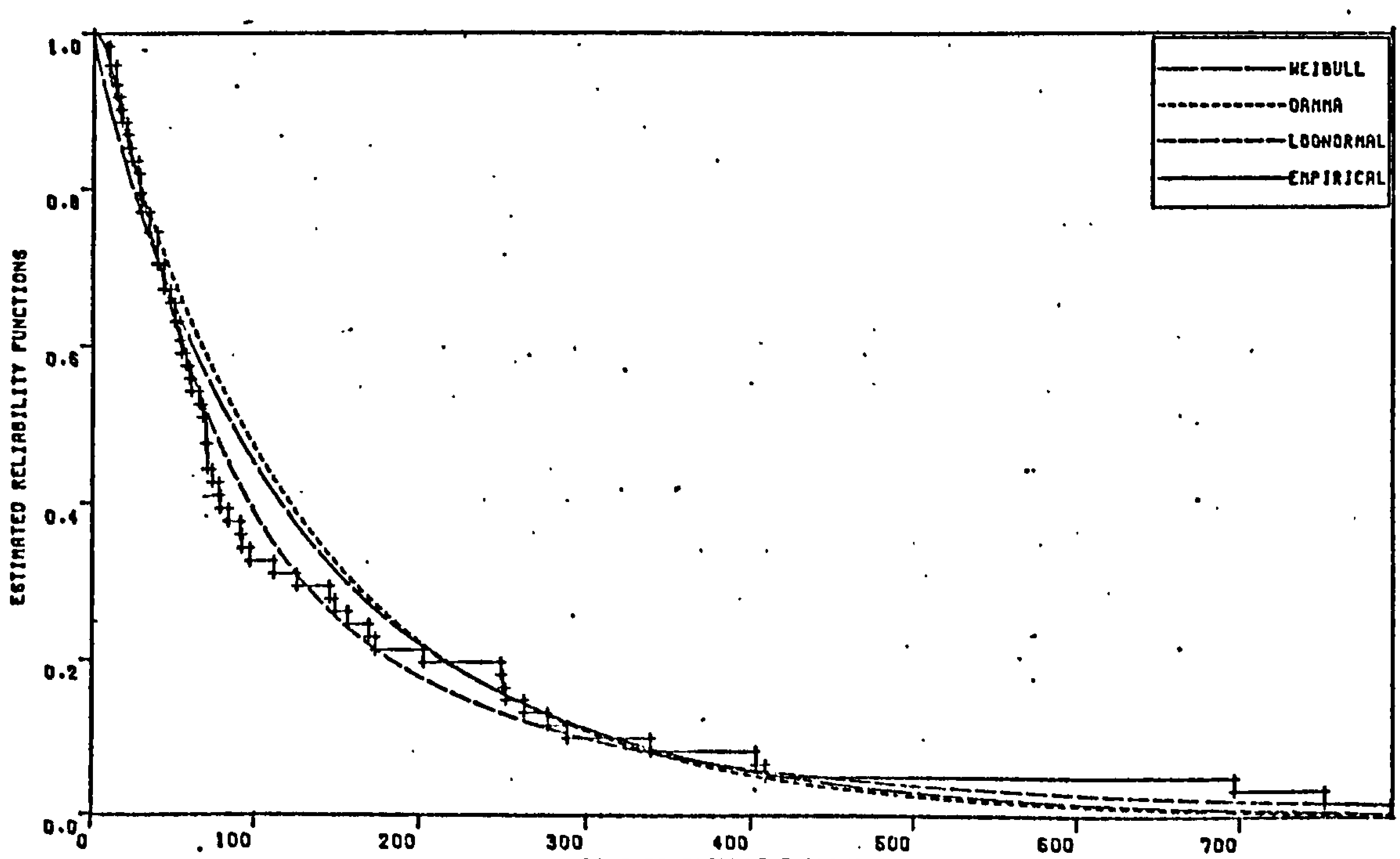


Fig. 4.51 FIG : RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

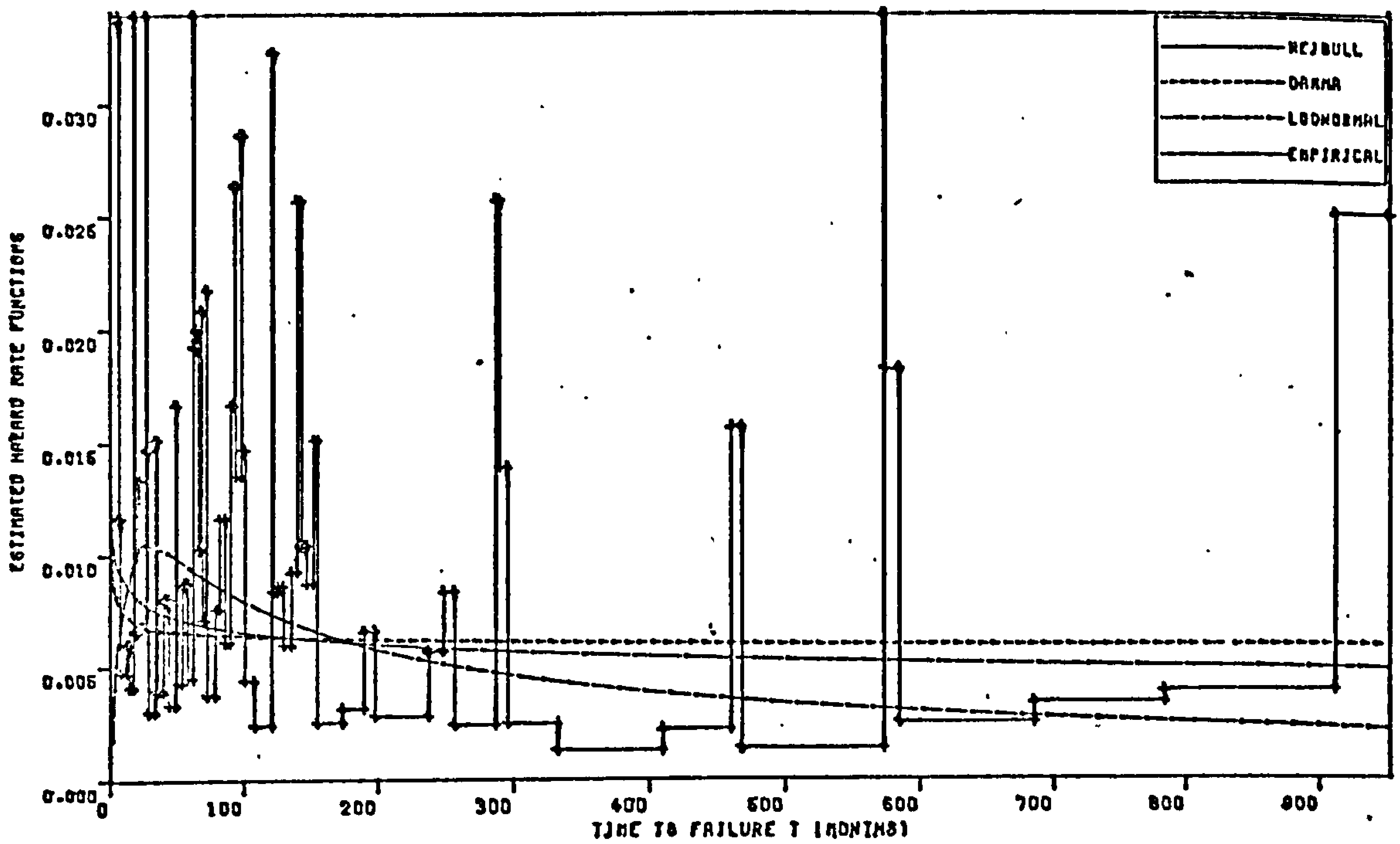


Fig. 4.52 FIG : HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1971

	SHAPE	SCALE
LOG-NORMAL	1.19	4.33
WEIBULL	0.86	139
GAMMA	0.57	262

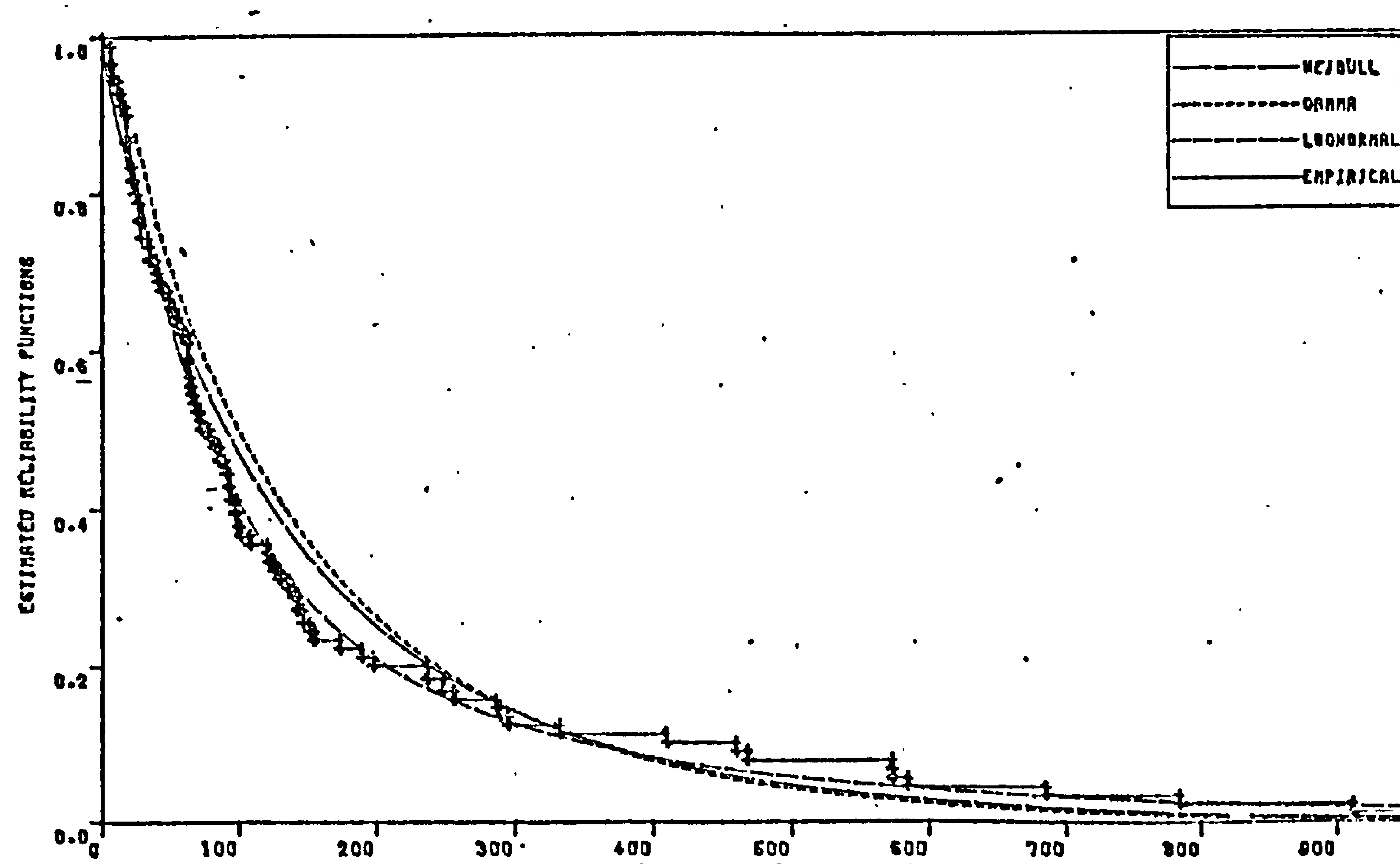


Fig. 4.53 FIG : RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

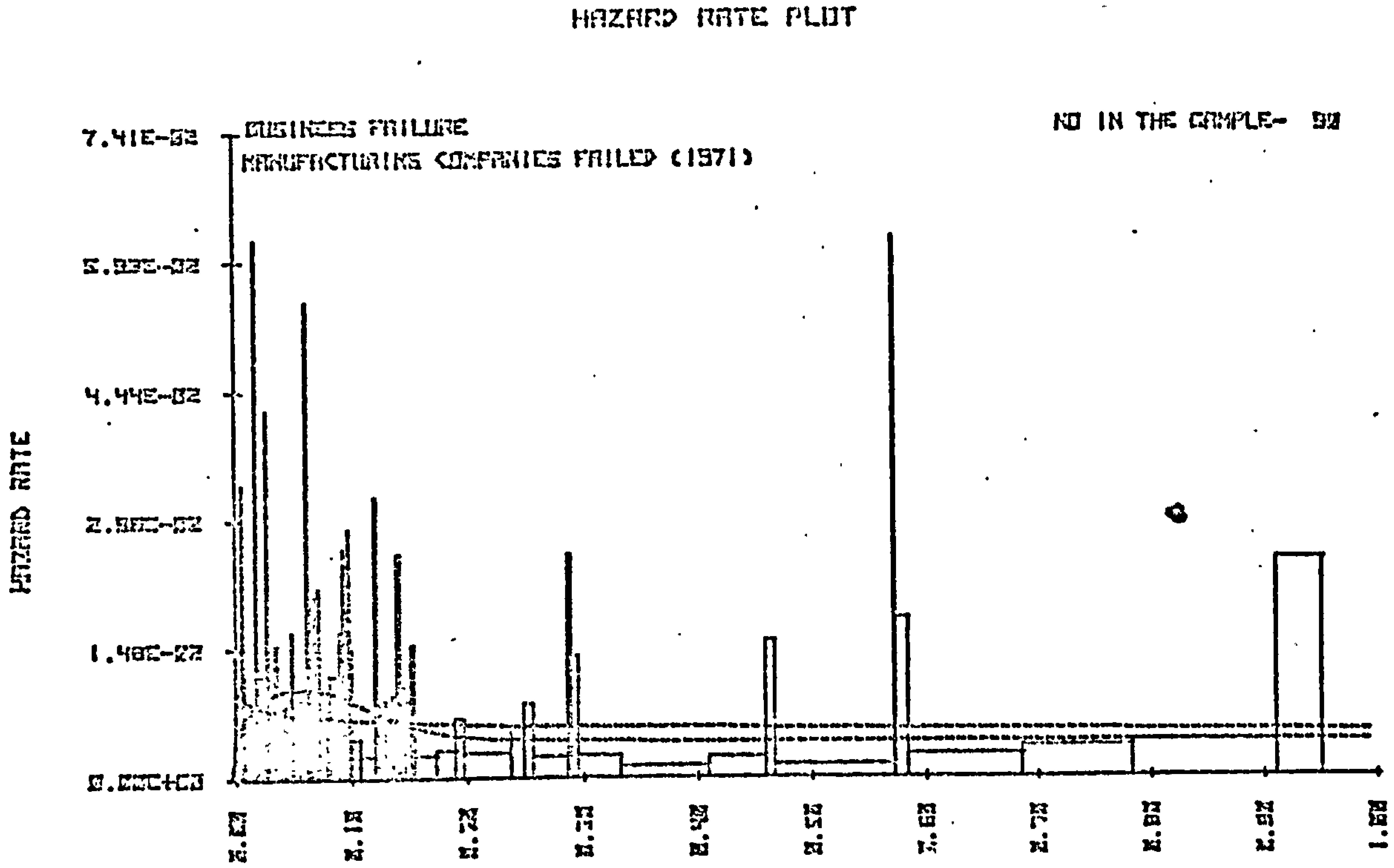


Fig. 4.54

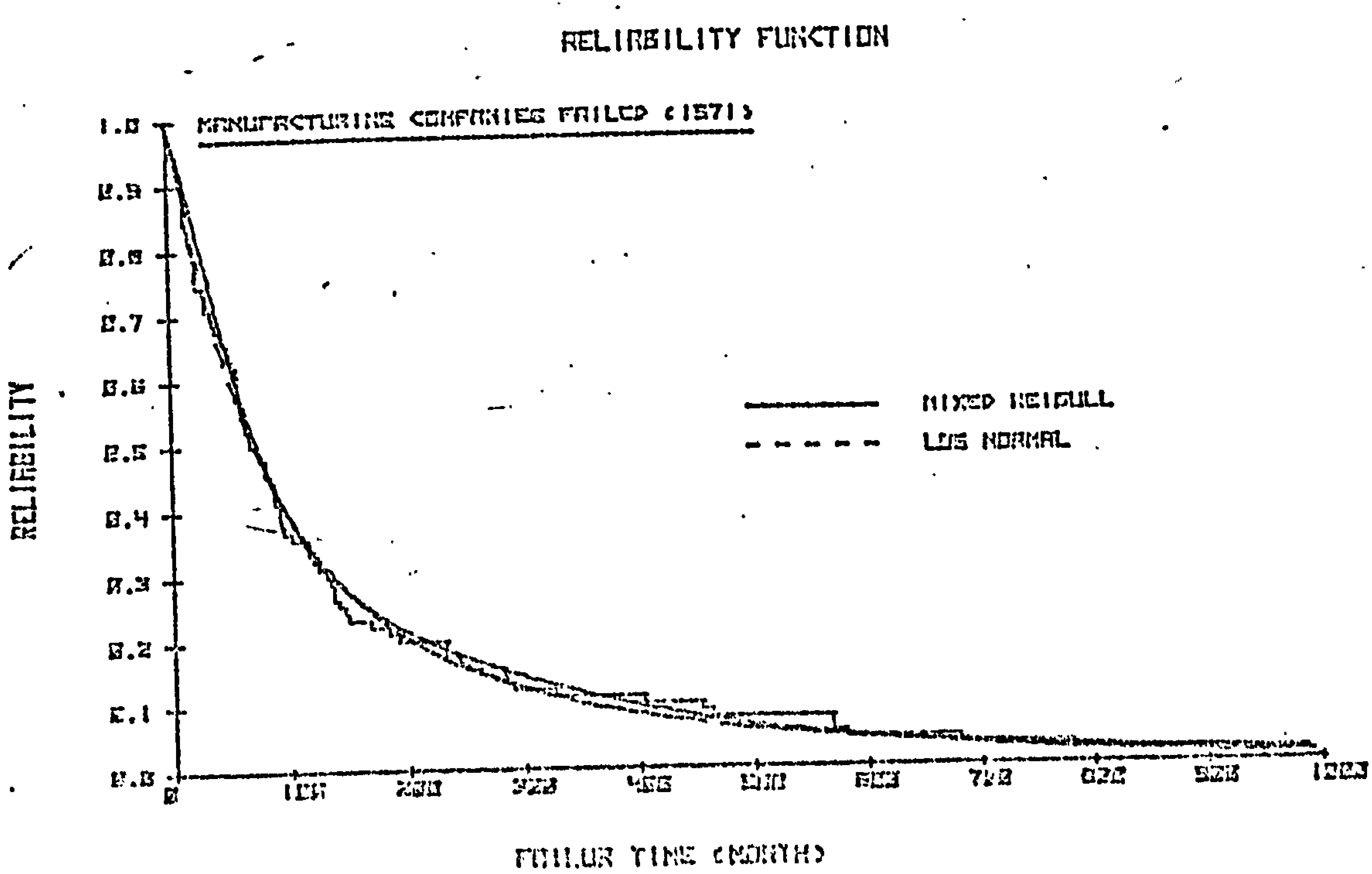


Fig. 4.55

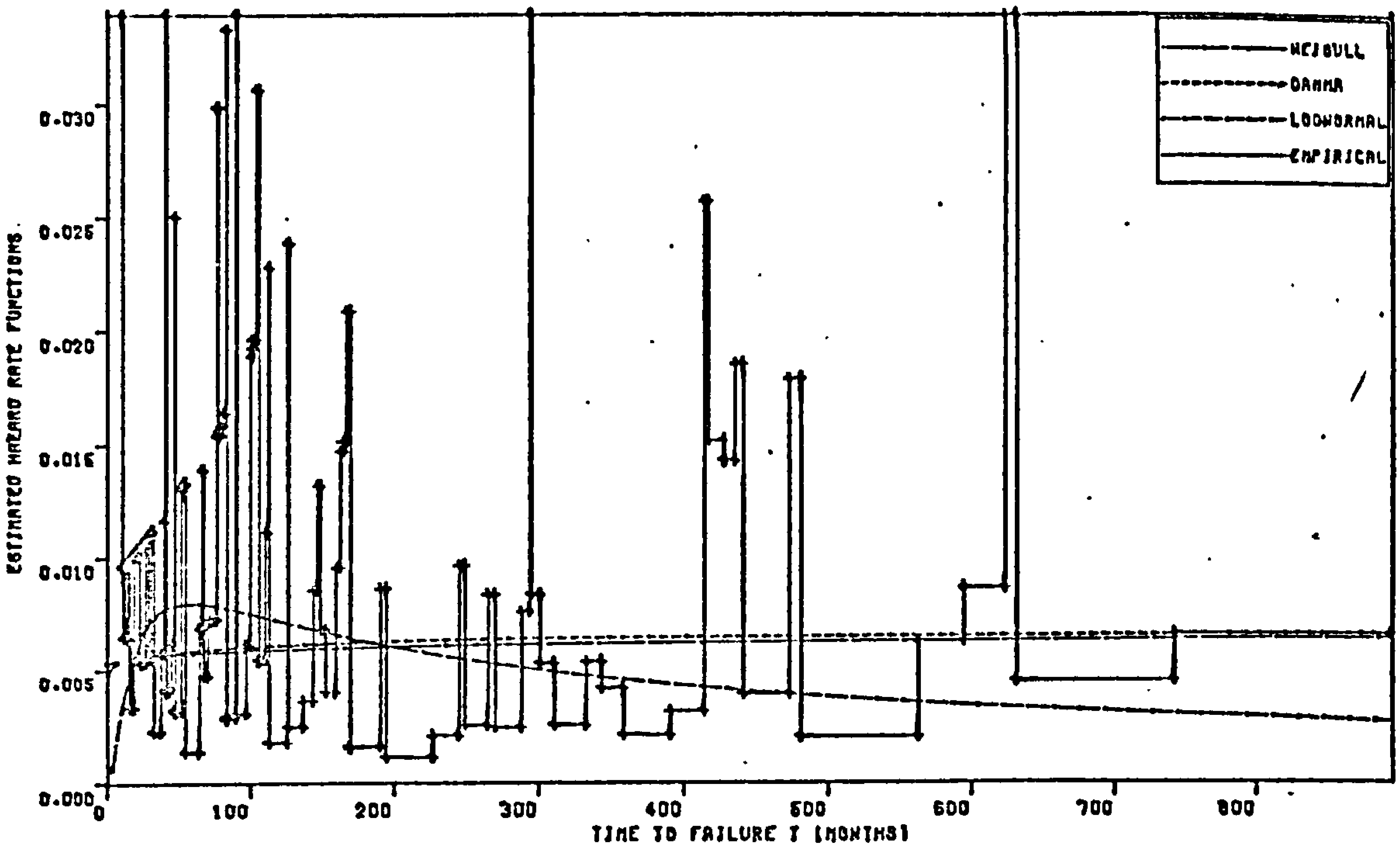


Fig. 4.56

FIG : HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1972

	SHAPE	SCALE
LOG-NORMAL	1.03	4.64
WEIBULL	1.03	173
GAMMA	0.93	184

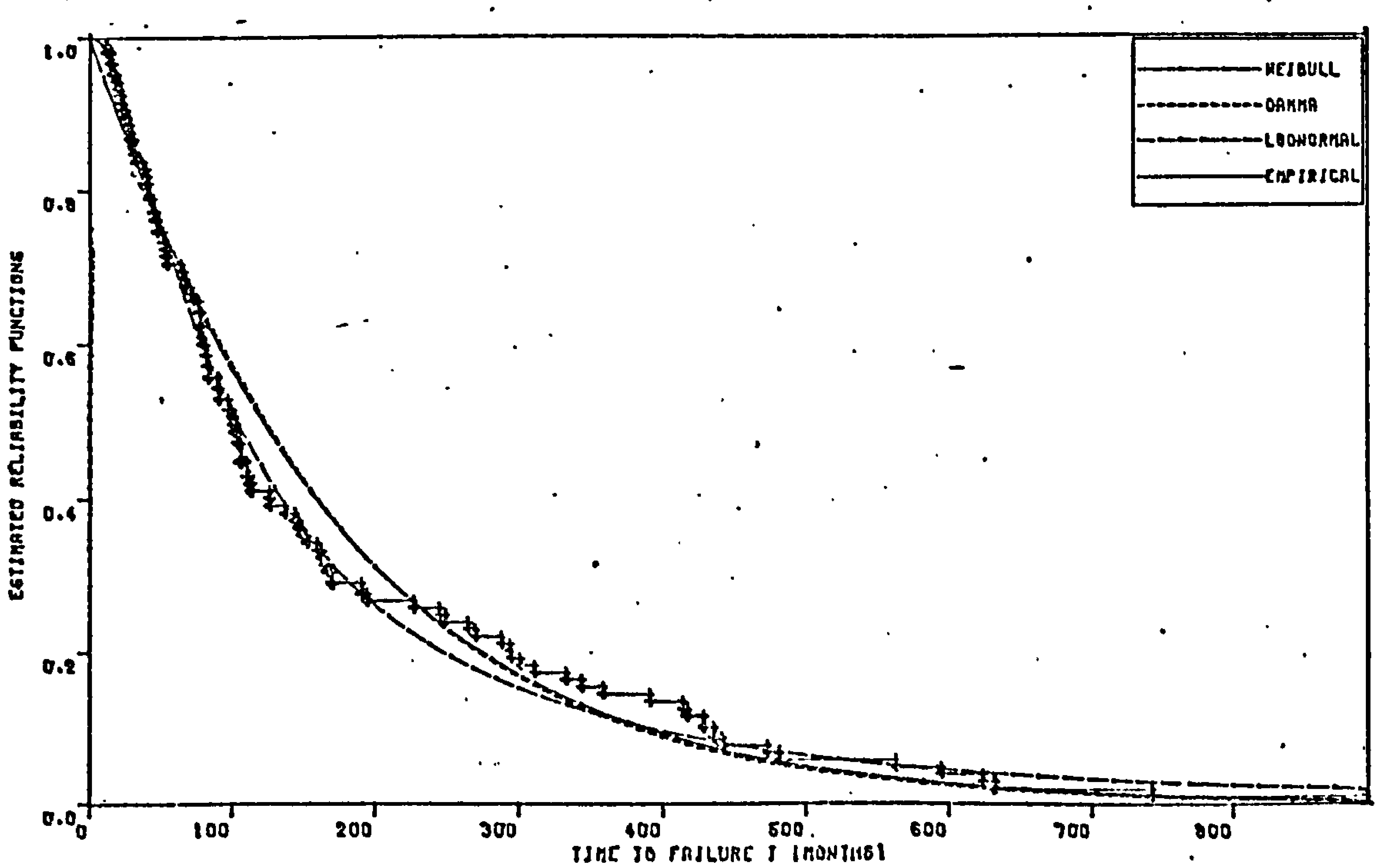


Fig. 4.57

FIG : RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

TABLE 4.11 Manufacturing Companies Failed in 1973

Distributions		D-Max	Parameters		Mean	Proportion of Failure	
			Shape	Scale		Early	Late
Weibull	Early	0.053	2.31	37		47.32	
	Late		1.19	206			52.68
Log-Normal		0.085	1.06	4.17	113		
Weibull		0.12	0.92	112	117		
Gamma		0.15	0.58	201	117		

Critical Value at 95% Significance Level = 0.115
No. in the Sample = 141

TABLE 4.12 Manufacturing Companies Failed in 1974

Weibull	Early	0.054	2.01	47		50.35	
	Late		1.23	188			49.65
Log-Normal		0.06	0.99	4.17	107		
Weibull		0.11	1.00	108	108		
Gamma		0.14	0.75	145	108		

Critical Value at 95% Significance Level = 0.102
No. in the Sample = 179

TABLE 4.13 Manufacturing Companies Failed in 1975

Weibull	Early	0.032	2.18	41		48.62	
	Late		1.25	223			51.38
Log-Normal		0.07	1.07	4.23	122		
Weibull		0.12	0.93	119	123		
Gamma		0.14	0.66	185	124		

Critical Value at 95% Significance Level = 0.078
No. in the Sample = 307

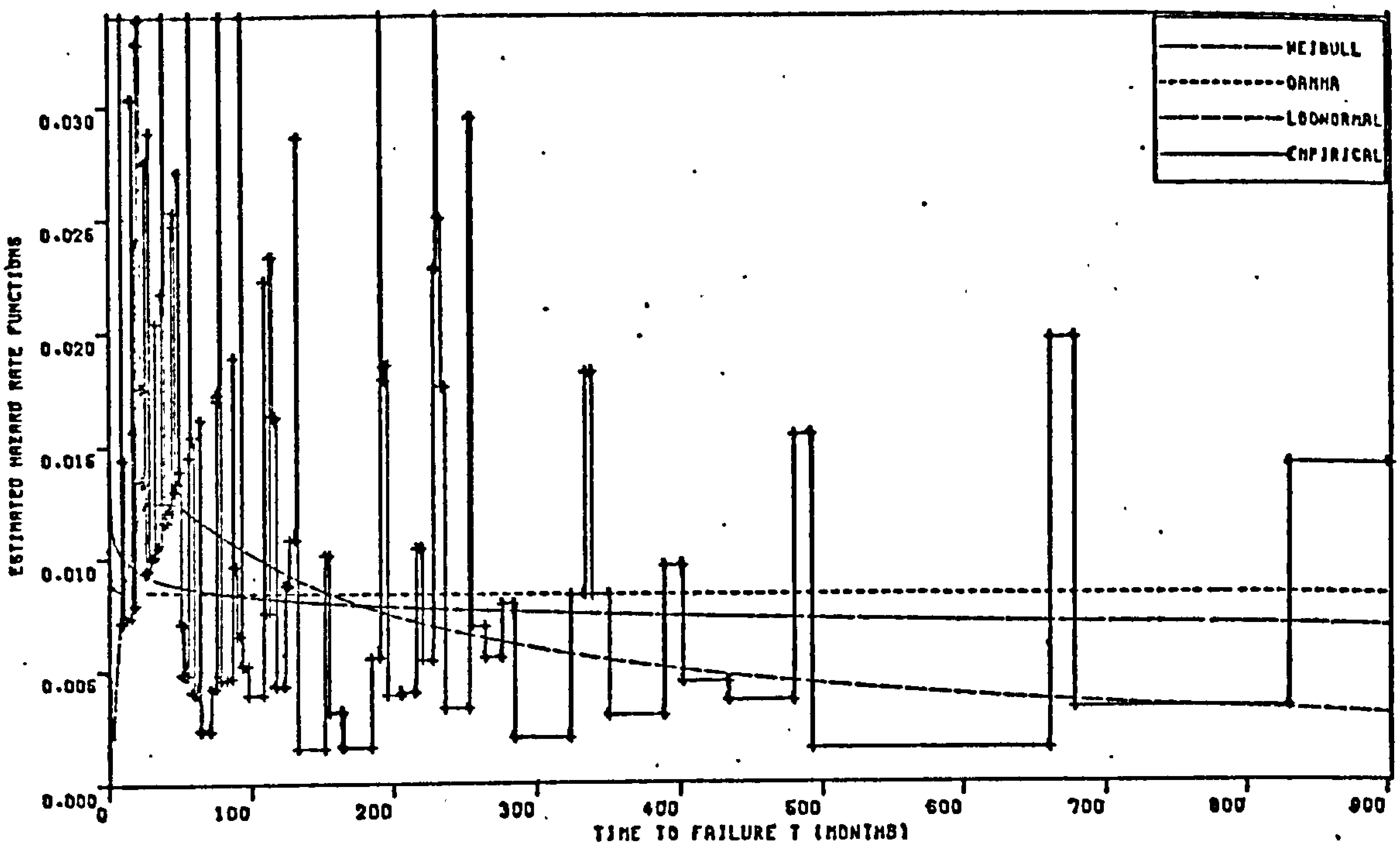


Fig. 4.58

FIG : HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1973

	SHAPE	SCALE
LOG-NORMAL	1.06	4.17
WEIBULL	0.92	112
GAMMA	0.58	201

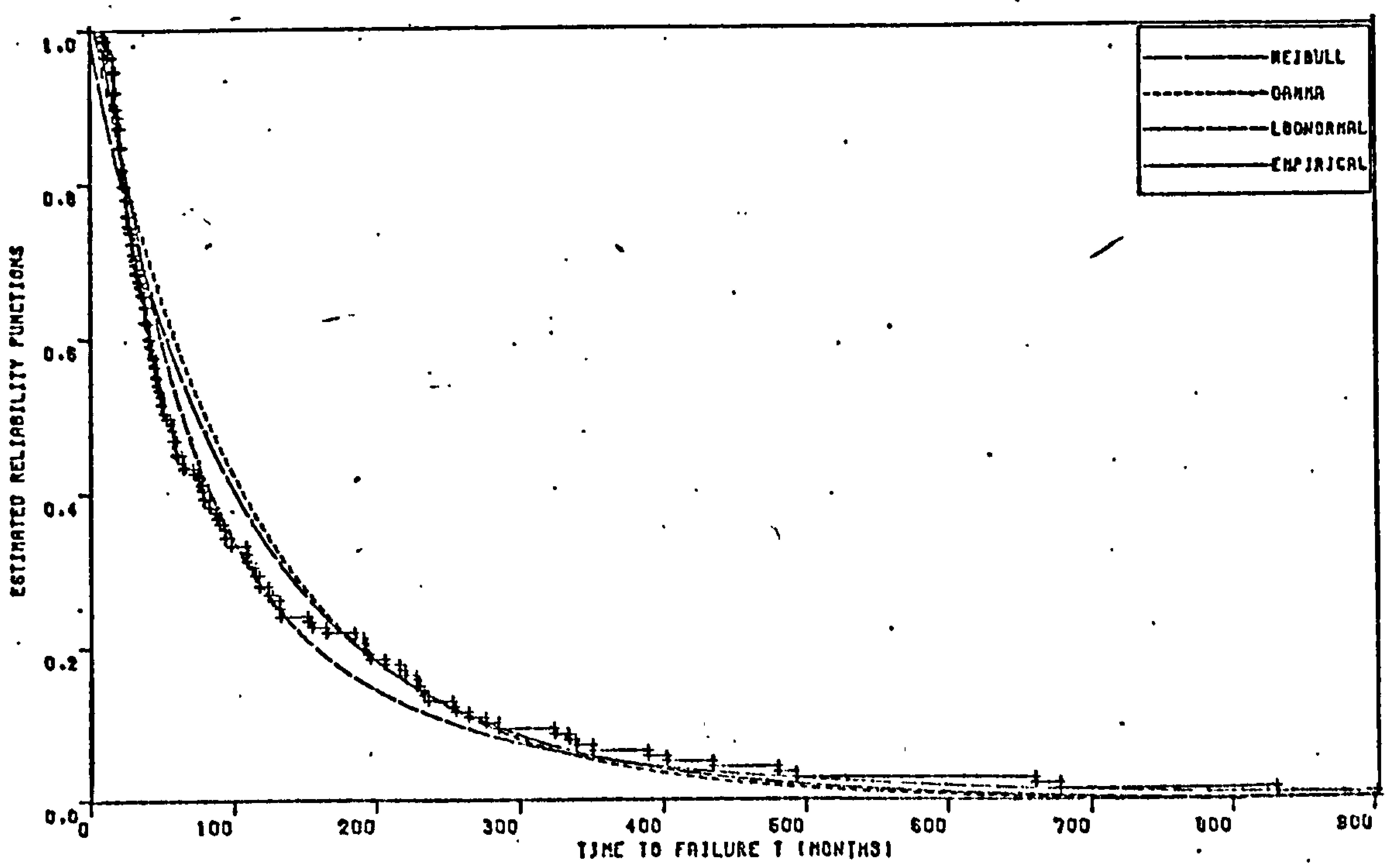


Fig. 4.59

FIG : RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

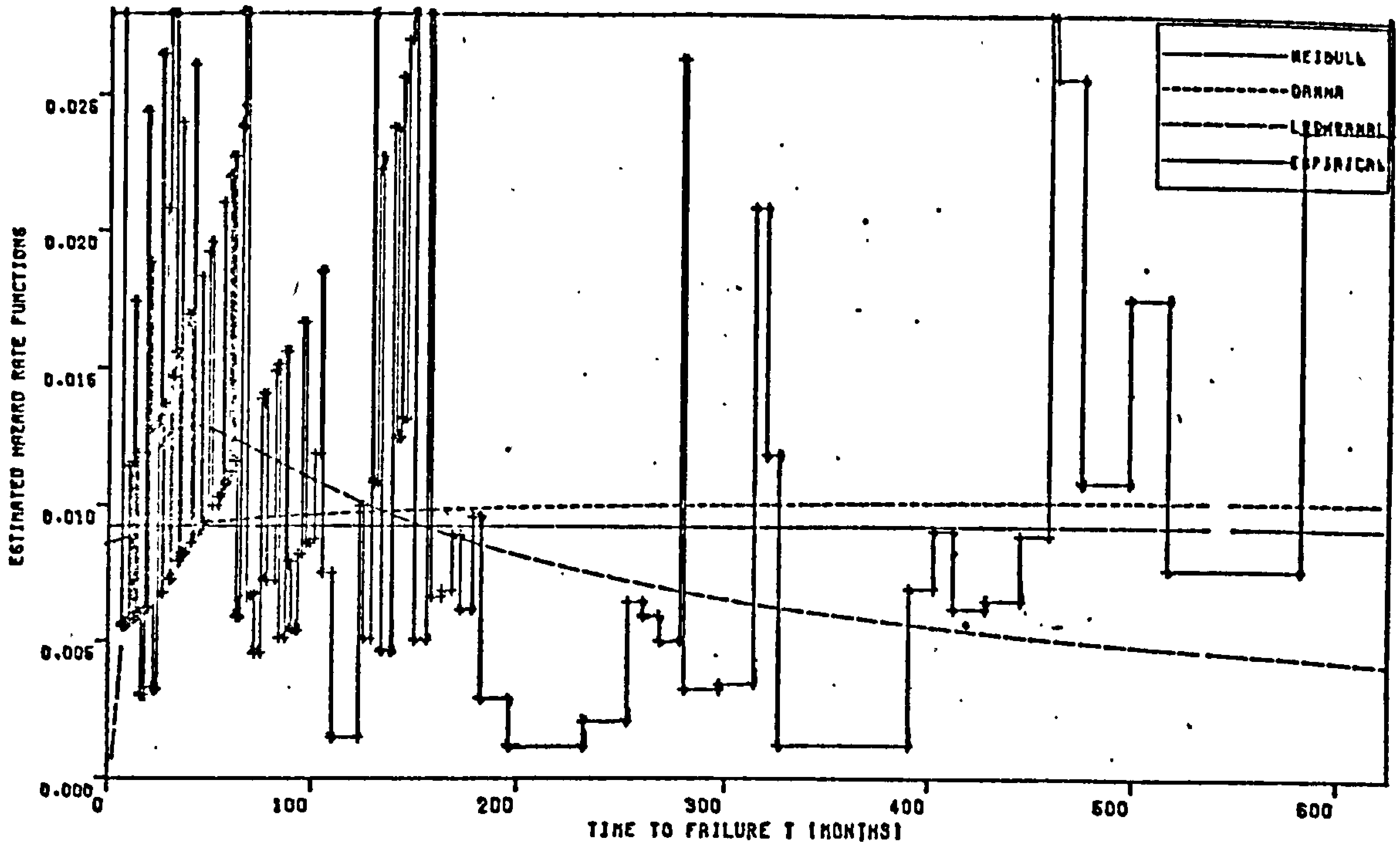


Fig. 4.60

FIG : HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1974

	SHAPE	SCALE
LOG-NORMAL	0.99	4.17
WEIBULL	1.00	108
GAMMA	0.75	145

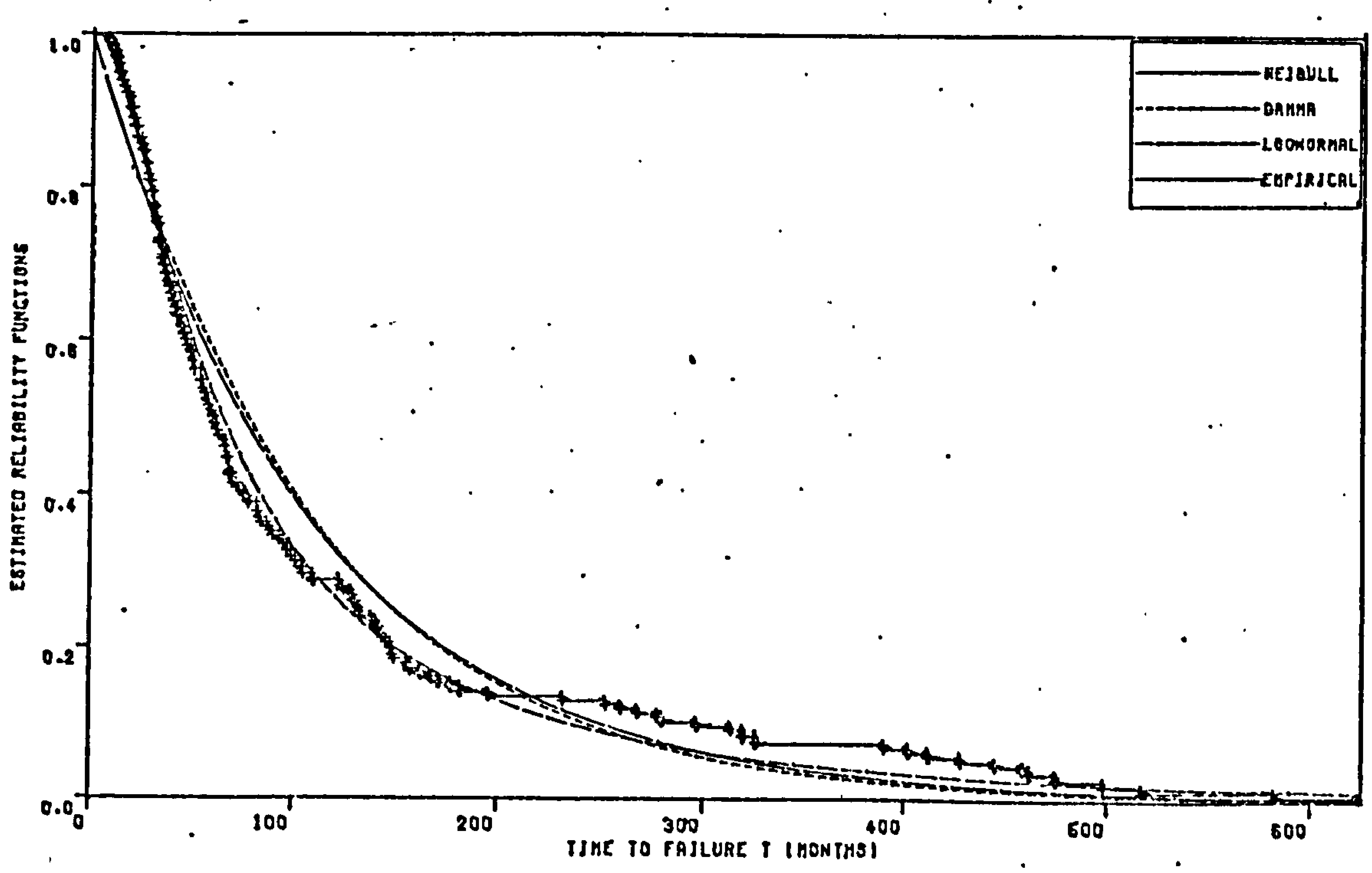


Fig. 4.61

FIG : RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

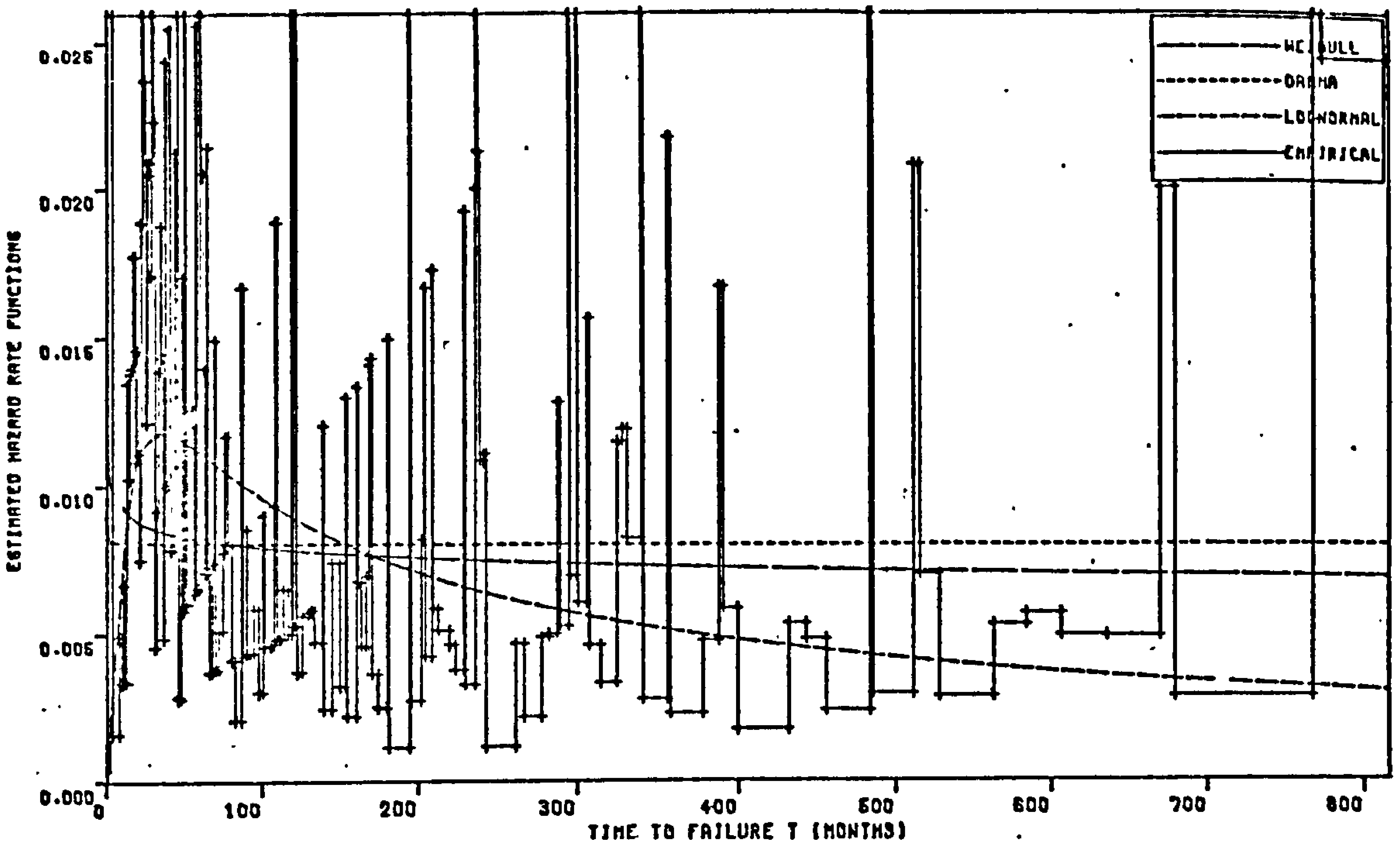


Fig. 4.62

FIG : HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1975

	SHAPE	SCALE
LOG-NORMAL	1.07	4.23
WEIBULL	0.93	119
GAMMA	0.66	185

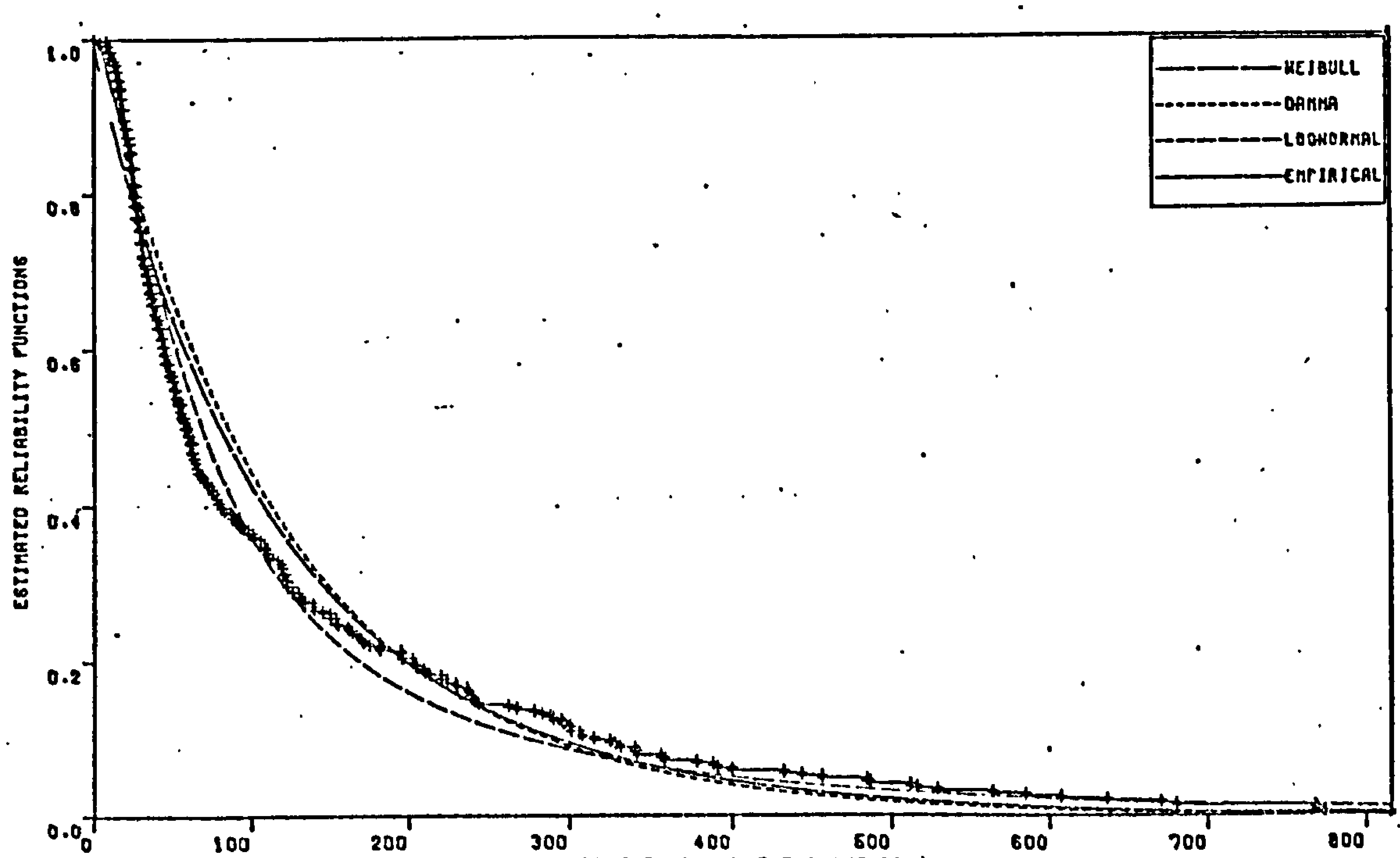


Fig. 4.63

FIG : RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

TABLE 4.14 Manufacturing Companies Failed in 1976

Distributions		D-Max	Parameters		Mean	Proportion of Failure	
			Shape	Scale		Early	Late
Weibull	Early	0.027	1.84	47		48.44	
	Late		1.21	247			51.56
Log-Normal		0.06	1.11	4.33	141		
Weibull		0.10	0.92	133	138		
Gamma		0.12	0.62	223	139		

Critical Value at 95% Significance Level = 0.062

No. in the Sample = 475

TABLE 4.15 Manufacturing Companies Failed in 1977

Weibull	Early	0.025	1.93	47		49.63	
	Late		1.25	219			50.37
Log-Normal		0.05	1.06	4.25	124		
Weibull		0.10	0.96	121	122		
Gamma		0.12	0.69	176	123		

Critical Value at 95% Significance Level = 0.066

No. in the Sample = 429

TABLE 4.16 Manufacturing Companies Failed in 1970-1977

Weibull	Early	0.023	1.85	48		49.36	
	Late		1.21	231			50.64
Log-Normal		0.041	1.08	4.28			
Weibull		0.092	0.937	126			
Gamma		0.14	0.66	198			

Critical Value at 95% Significance Level = 0.032

No. in the Sample = 1787

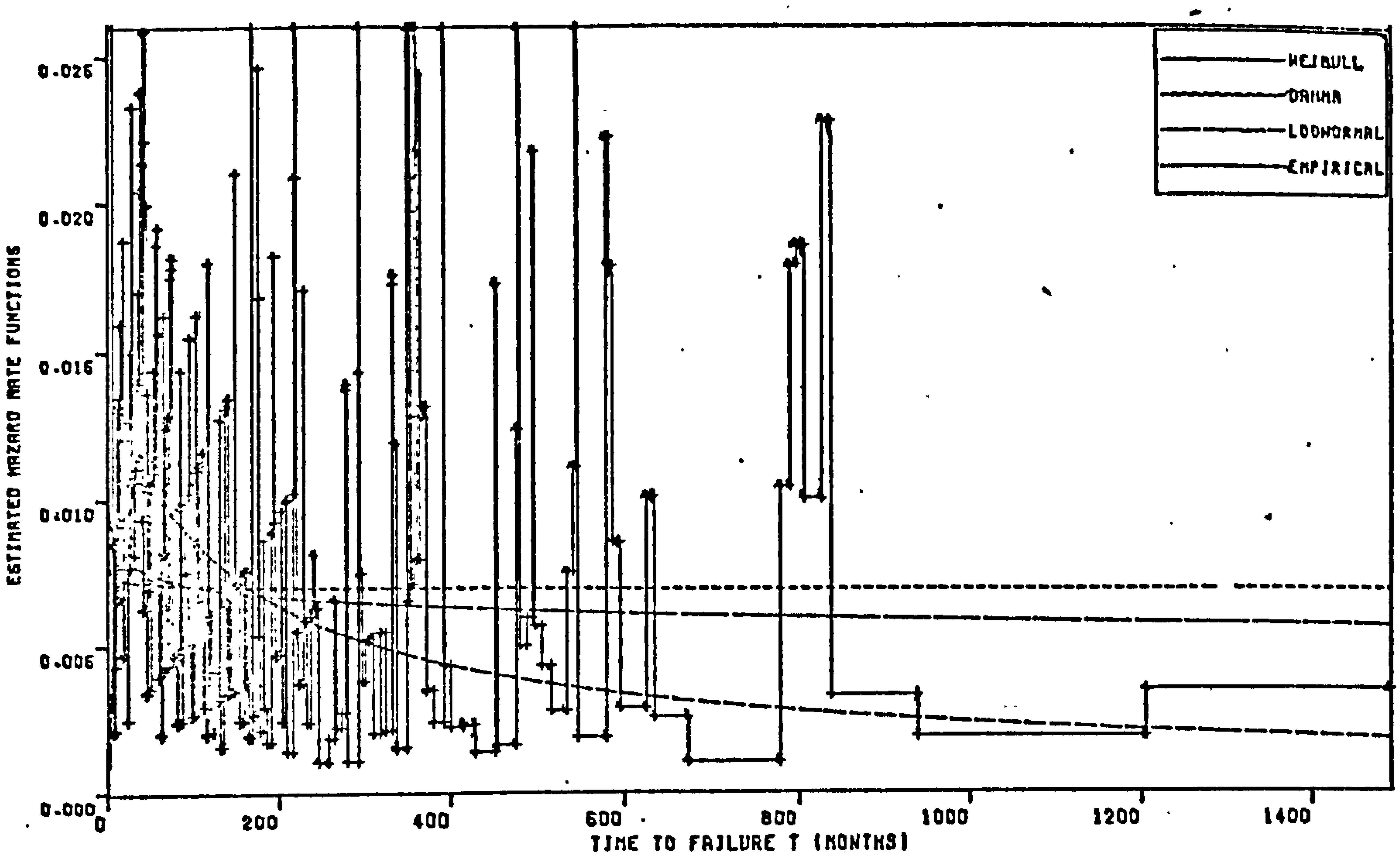


Fig. 4.64

FIG : HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1976

	SHAPE	SCALE
LOG-NORMAL	1.11	4.33
WEIBULL	0.92	133
GAMMA	0.62	223

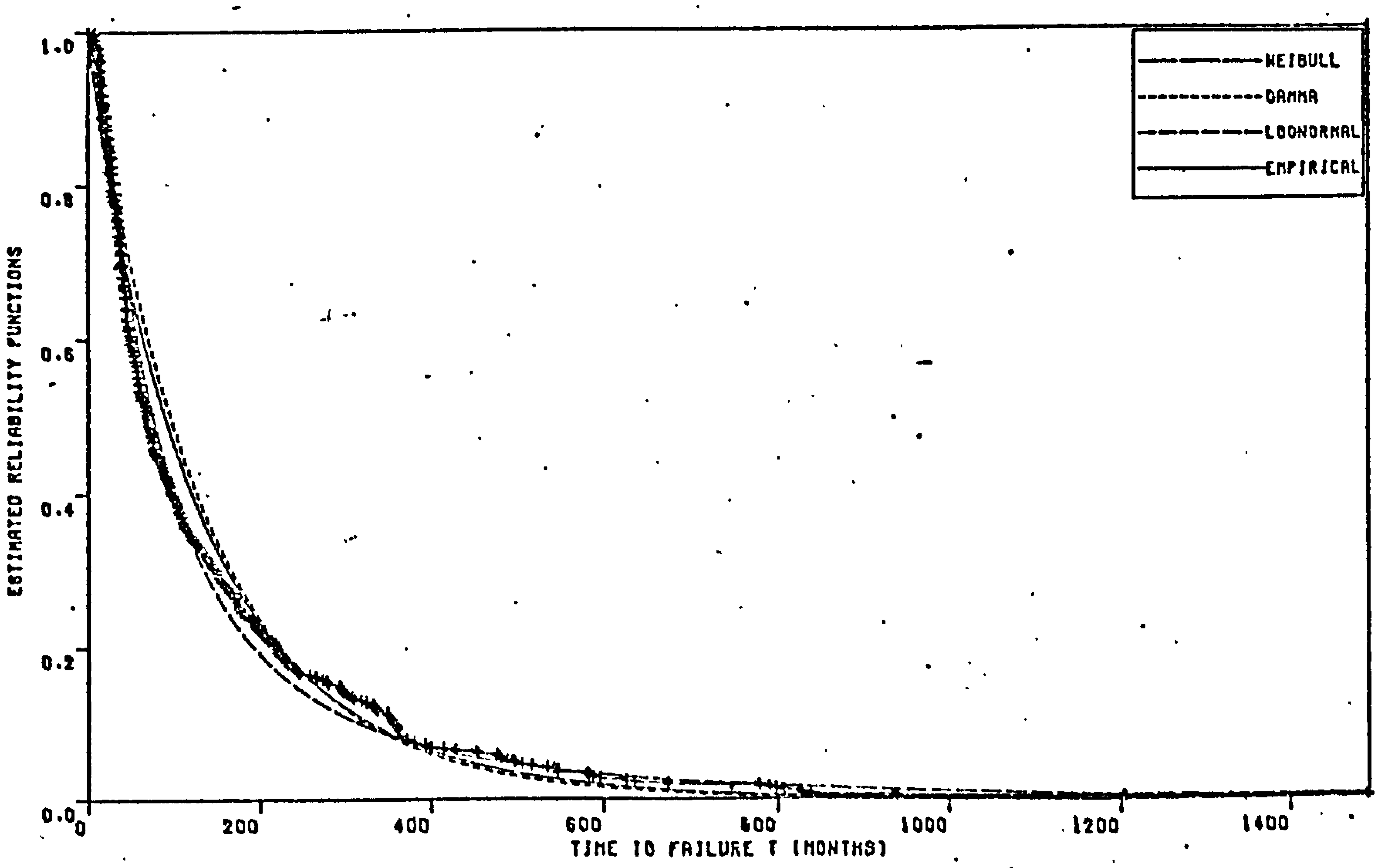


Fig. 4.65

FIG : RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

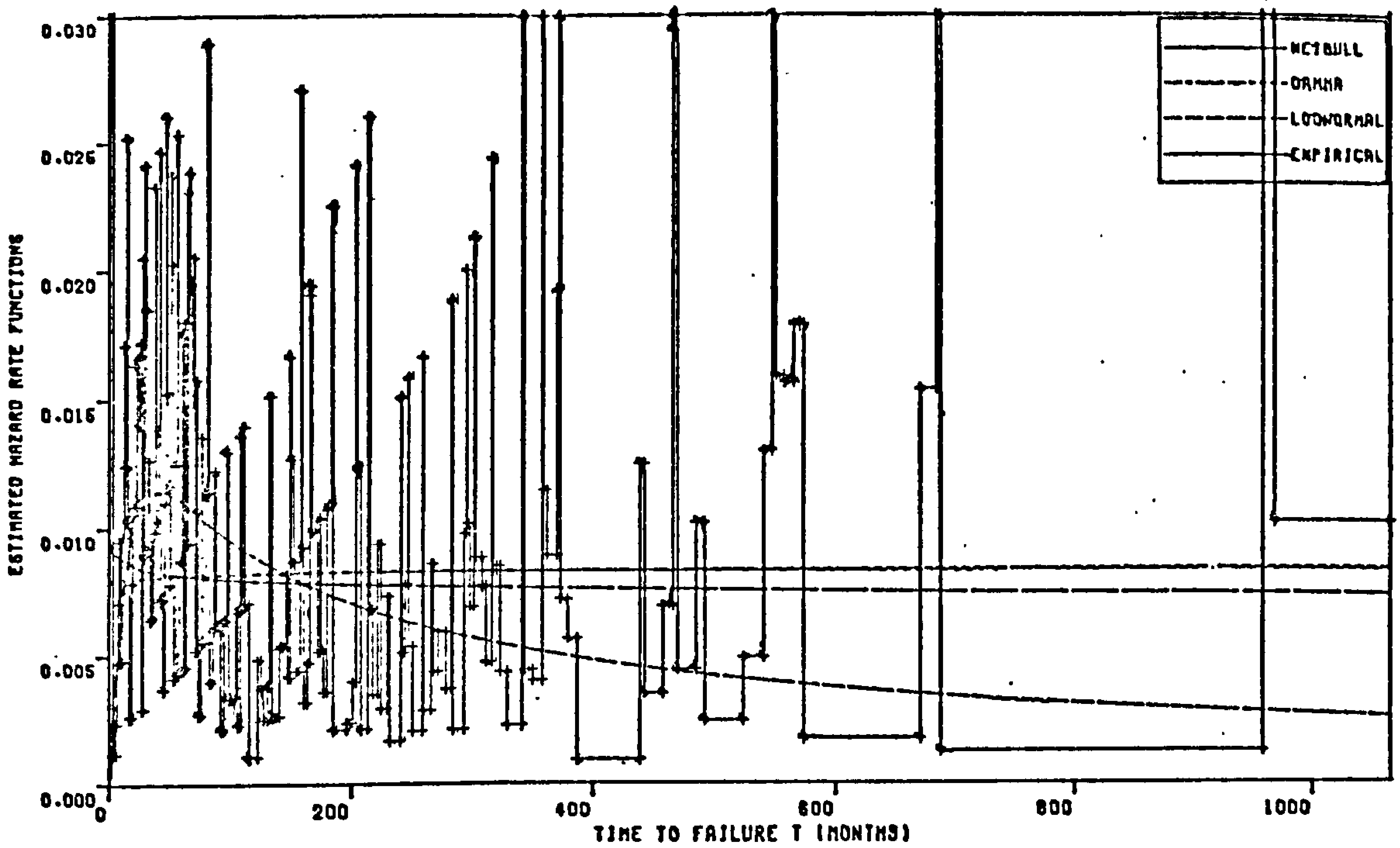


Fig. 4.66 FIG : HAZARD RATE FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1977

	SHAPE	SCALE
LOG-NORMAL	1.06	4.25
WEIBULL	0.96	121
GAMMA	0.69	176

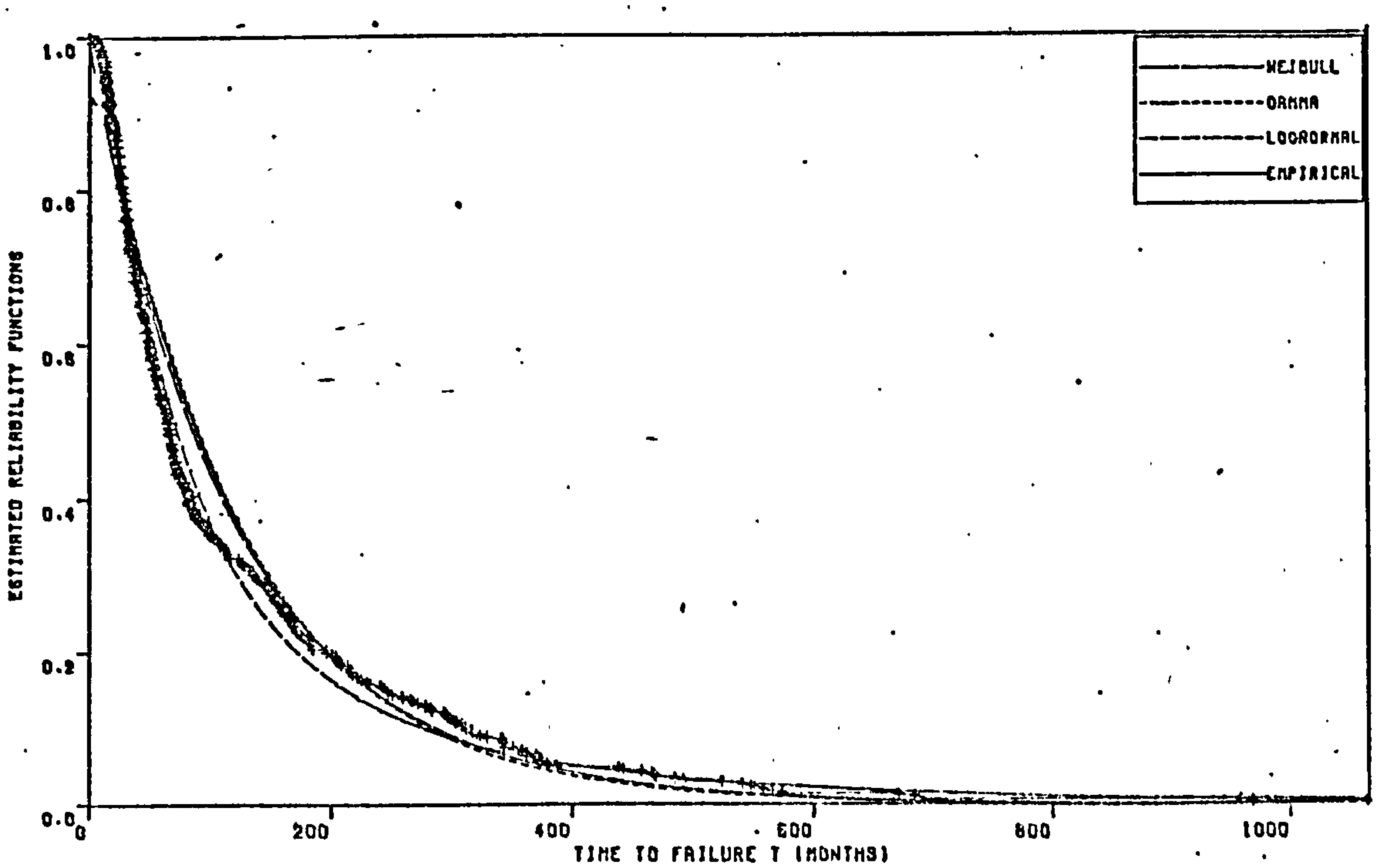


Fig. 4.67 FIG : RELIABILITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

TABLE 4.17 Food, Drink and Tobacco

Distributions		D-Max	Parameters Shape	Parameters Scale	Mean	Proportion of Failure Early	Proportion of Failure Late
Weibull	Early	0.095	0.91	63.68		49.73	
	Late		1.15	220			50.27
Log-Normal		0.146	1.33	4.23	167.4		
Weibull		0.090	0.88	130.0	138		
Gamma		0.175	0.73	190	138		

Critical Value at 95% Significance Level = 0.198

No. in the Sample = 47

TABLE 4.18 Chemicals and Allied Industries

Weibull	Early	0.054	1.82	47.5		47.77	
	Late		1.71	205			52.33
Log-Normal		0.076	0.99	4.31	121		
Weibull		0.090	1.12	121	116		
Gamma		0.18	1.11	104	116		

Critical Value at 95% Significance Level = 0.196

No. in the Sample = 48

TABLE 4.19 Metal Manufacture

Weibull	Early	0.071	2.50	60		52.29	
	Late		3.57	284			47.71
Log-Normal		0.133	0.97	4.62	163		
Weibull		0.18	1.26	161	150		
Gamma		0.26	1.61	93	150		

Critical Value at 95% Significance Level = 0.23

No. in the Sample = 35

TABLE 4.20 Mechanical Engineering

Distributions		D-Max	Parameters		Mean	Proportion of Failure	
			Shape	Scale		Early	Late
Weibull	Early	0.035	1.97	48.45		49.85	
	Late		1.91	209			50.15
Log-Normal		0.053	1.03	4.24	118		
Weibull		0.10	0.96	117.8	119.6		
Gamma		0.12	0.66	181	119.6		

Critical Value at 95% Significance Level = 0.082

No. in the Sample = 278

TABLE 4.21 Instrument Engineering

Weibull	Early	0.117	1.92	62		53.83	
	Late		1.78	220			43.17
Log-Normal		0.110	0.92	4.39	123		
Weibull		0.16	1.18	128	120		
Gamma		0.15	1.21	99	120		

Critical Value at 95% Significance Level = 0.32

No. in the Sample = 18

TABLE 4.22 Electrical Engineering

Weibull	Early	0.053	2.28	46		51.78	
	Late		1.12	161			48.22
Log-Normal		0.074	0.91	4.080			
Weibull		0.12	1.00	96			
Gamma		0.23	0.59	161			

Critical Value at 95% Significance Level = 0.127

No. in the Sample = 114

TABLE 4.23 Shipbuilding and Marine Engineering.

Distributions		D-Max	Parameters		Mean	Proportion of Failure	
			Shape	Scale		Early	Late
Weibull	Early	0.066	2.67	35		44.72	
	Late		1.25	194			55.28
Log-Normal		0.10	1.06	4.19	116		
Weibull		0.13	0.96	111	113		
Gamma		0.15	0.65	172	113		

Critical Value at 95% Significance Level = 0.205

No. in the Sample = 44

TABLE 4.24 Vehicles

Weibull	Early	0.063	1.94	50		52.05	
	Late		1.08	206			47.95
Log-Normal		0.096	1.06	4.19	1.16		
Weibull		0.14	0.92	114	118		
Gamma		0.16	0.61	196	119		

Critical Value at 95% Significance Level = 0.209

No. in the Sample = 42

TABLE 4.25 Metal Goods

Weibull	Early	0.034	1.79	64		50.93	
	Late		1.06	244			49.07
Log-Normal		0.058	1.04	4.40	141		
Weibull		0.10	0.93	140	144		
Gamma		0.12	0.54	270	145		

Critical Value at 95% Significance Level = 0.111

No. in the Sample = 150

TABLE 4.26 Textiles

Distributions		D-Max	Parameters		Mean	Proportion of Failure	
			Shape	Scale		Early	Late
Weibull	Early	0.050	1.62	65		47.06	
	Late		1.68	456			52.94
Log-Normal		0.089	1.21	4.87	270		
Weibull		0.09	0.93	235	242		
Gamma		0.11	0.90	268	242		

Critical Value at 95% Significance Level = 0.145

No. in the Sample = 88

TABLE 4.27 Leather, Leather Goods and Fur

Weibull	Early	0.058	2.89	44		51.14	
	Late		1.56	301			48.86
Log-Normal		0.155	1.10	4.43	155		
Weibull		0.17	0.94	148	152		
Gamma		0.19	0.80	190	152		

Critical Value at 95% Significance Level = 0.23

No. in the Sample = 35

TABLE 4.28 Clothing and Footwear

Weibull	Early	0.032	1.74	44		49.11	
	Late		1.65	205			50.89
Log-Normal		0.076	1.10	4.29	134		
Weibull		0.11	0.96	127	129		
Gamma		0.12	0.76	170	129		

Critical Value at 95% Significance Level = 0.081

No. in the Sample = 277

TABLE 4.29 Bricks, Pottery, Glass & Cement, etc.

Distributions		D-Max	Parameters		Mean	Proportion of Failure	
			Shape	Scale		Early	Late
Weibull	Early	0.055	2.48	49		56.06	
	Late		1.12	225			43.94
Log-Normal		0.13	1.00	4.21	111		
Weibull		0.18	0.93	114	118		
Gamma		0.21	0.59	200	119		

Critical Value at 95% Significance Level = 0.183

No. in the Sample = 55

TABLE 4.30 Timber, Furniture, etc.

Weibull	Early	0.039	2.01	37.26		47.64	
	Late		1.43	220			52.36
Log-Normal		0.066	1.09	4.21	123		
Weibull		0.10	0.96	117.3	119		
Gamma		0.11	0.80	149	119		

Critical Value at 95% Significance Level = 0.088

No. in the Sample = 239

TABLE 4.31 Paper, Printing & Publishing

Weibull	Early	0.043	1.80	48		50.16	
	Late		1.09	229			49.84
Log-Normal		0.064	1.09	4.25	128		
Weibull		0.17	0.89	123	130		
Gamma		0.13	0.56	235	131		

Critical Value at 95% Significance Level = 0.088

No. in the Sample = 239

TABLE 4.32 Other Manufacturing

Distributions		D-Max	Parameters		Mean	Proportion of Failure	
			Shape	Scale		Early	Late
Weibull	Early	0.064	1.99	40		51.80	
	Late		1.24	181			48.20
Log-Normal		0.088	1.04	4.05	99		
Weibull		0.125	0.97	98	99		
Gamma		0.14	0.70	141	99		

Critical Value at 95% Significance Level = 0.154

No. in the Sample = 78

TABLE 4.33 All Types of Manufacturing Companies

Weibull	Early	0.023	1.85	48		49.36	
	Late		1.21	231			50.64
Log-Normal		0.041	1.08	4.28			
Weibull		0.092	0.937	126			
Gamma		0.14	0.66	198			

Critical Value at 95% Significance Level = 0.032

No. in the Sample = 1787

TABLE

Weibull	Early						
	Late						
Log-Normal							
Weibull							
Gamma							

Critical Value at 95% Significance Level =

No. in the Sample =

4.7 Conclusions

Although the Weibull, log-normal, Gamma and mixed Weibull distributions appear to be particularly appropriate to use in the analysis of company failure data, it was found that mixed Weibull can best represent the various phases of a company life cycle, due to its properties and flexibility which were mentioned earlier, e.g. Fig. 4.34, 4.35 and Table 4.5.

It is considered that companies are most at risk during the early period of formation (1 to 3 years). This high risk experienced at the early stages is most likely due to problems encountered with regard to market penetration and the difficulties of entering and operating in a highly competitive business environment. In the present study this initial stage is defined as 'Introductory Phase'. Among the emergent mix of companies are several entities dependent on one product or process. These companies are particularly at risk when introducing a newly developed product, and as a consequence suffer a high mortality rate.

During the latter stages when the company has established itself and assured a relatively stable market for its product, the chances of failure are decreasing. This is referred to as the 'Growth Phase' which is followed by the 'Maturity Phase' when the company enters a stagnation period. The chances of failure are more likely to be random and arise from inherent deficiencies associated with the organisational and management structure. The mixed Weibull distribution can also describe the 'Declining Phase' of company life cycle when both sales and profit fall repeatedly and cash flow balance progressively deteriorates until the company is forced into liquidation. Hazard rate characteristics of the mixed Weibull distribution appears to describe the various phases of failure, depending upon the value of parameters. Having concluded that the mixed Weibull model is the best fit for company failure data, one can possibly draw attention to the strengths and weaknesses of the other distributions examined in this study. Tables 4.1 to 4.4

Hazard rate characteristics of the log-normal distribution appears to describe the phenomena of high mortality rate during the 'Introductory Phase' and a gradual decrease of the 'Growth Phase'. However, since the hazard rate tends to be zero over time the 'Declining Phase' cannot be represented by this distribution e.g. Fig. 4.9.

Gamma distribution on the other hand can be used for the 'Growth and Maturity Phases' of company life cycle assuming that the duration of the initial stage is significantly small. This distribution has a monotonically decreasing hazard rate characteristics with limiting positive failure rate with time, e.g. Fig. 4.5.

Finally, the Weibull distribution with a shape parameter less than 1.00 adequately represents the 'Growth Phase' of the company life cycle. It suffers from the same weakness of log-normal distribution where the limiting hazard rate is zero. It is interesting to note that for the shape parameter greater than 1.00 the 'Declining Phase' can be adequately described, e.g. Fig. 4.7.

For the comparison of failure behaviour of companies, the hazard and reliability plots for various groups, fitted in different distributions, are given in this chapter and Appendix B. Fig. 4.3 to 4.30.

CHAPTER FIVE

APPLICATION OF RISK MANAGEMENT METHODOLOGY TO THE ANALYSIS AND IDENTIFICATION OF CAUSES AND SYMPTOMS OF COMPANY FAILURE

5. Application of Risk Management Methodology to the Analysis of Causes and Symptoms of Company Failure

5.1 Introduction

Although one is primarily interested in the successful aspects of growing concerns, there is much to be learned by studying the characteristics of failed companies. Mistakes often result in more management lessons than success stories.

It is difficult to identify specific causes of failure in any individual case. A whole series of contributing circumstances would lead up to the final collapse. One of the best ways of identifying causes is by following the history of a firm from beginning to the end and considering all the ups and downs in its fortunes.

Causes of business failure are generally described in simplified terms. Some people[11] see companies fail because they are greedy, others suggest management is the critical factor; directors often blame government and economic situations; experts give obvious causes and symptons invariably with little distinction between these two.

On close examination, such explanations are ambiguous and inadequate as they are all single factor theories advanced to explain complex phenomena. There is no reason to think that any company is any exception to the rule that each business success, especially when it is rapid, carries within it 'bacteria' which may ultimately 'rot it away'. In the analysis of causes and symptoms of company failure, the way one looks at the problems depends to some degree on individual philosophy.

The methodology adopted in this chapter is based on a risk management methodology which can be applied to the identification of threats, risks and critical factors which caused the companies to fail. The scope and concept of risk management are described later in this chapter. The plan of this chapter is in the following order:

1. Analysis of specific individual company history.
2. A general review of the evolution and development of companies
3. A brief review of the problems and causes of failure in small businesses.
4. A compilation of causes of large company failure.
5. A list of non-financial symptoms exhibited by failed companies in a classified form according to functional areas.
6. Analysis of critical factors of company failure and development of an illustrative model for change appraisal.

5.2 Objectives

In recent years a significant volume of research has been carried out into aspects of corporate collapse and business failure, including pre- and post-bankruptcy behaviour. One particular area which has not been studied in detail is the analysis of causes and symptoms of failure. This is crucial to other related studies e.g. prediction, prevention and rescue operations.

It can however be noted that most of the studies to date on this topic have been carried out by Americans, except for a few which were based on British companies, i.e. Bosewell[28], Brough[31], Argenti[4]. The present study is one of the first attempts carried out to identify the causes and symptoms of company failure based on a detailed analysis of recently failed companies.

The present chapter is devoted to the application of risk management methodology to the identification of the threats and risks which are generally ignored by companies that eventually fail.

The importance of analysis has been stressed by many authors, in particular Argenti quotes "for too long managers and writers on management have shown the tourist the new and sparkling city centre, so to speak, and carefully kept him away from the slums and shanty towns". The avoidance of failure is as much a part of a manager's job as the achievement of success. An attempt to untangle the causes of failure could be beneficial not only to management, but it would also help guide further research in other rewarding directions. A final purpose of the present chapter is an attempt to find a common pattern of failure behaviour including deficiences in management. An objective of this subsidiary study was to see if "lessons" could be identified for other companies at risk.

5.3 Risk Management

Risk management is a wide concept with no standard definition, but it is generally taken as embracing the following functions, as A.P. Benson(19) defines:

1. The identification and evaluation of potential threats to corporate assets and profits.
2. The measure of the potential loss which these threats may cause if they occur.
3. The making of decisions aimed at the limitation or reduction to acceptable levels of these threats.
4. The taking of such other steps as may be necessary to protect the corporation against the balance of residual risk.

This definition suggests, quite correctly, that there can be no single measure of risk in corporate affairs. There is a need in the large corporation for a risk co-ordinator to bring together the disciplines which may contribute to the managing of risk and to ensure that a consistent and coherent approach to matters of risk is adopted.

J.R. Parkinson(117) provides a valuable summary of the current practice of risk management and defines the functions, describes the activity and shows clearly the role of risk management within a given company. He comments that "the function of the risk manager is not to 'manage' risk. He may manage the handling or financing of risk, but only those in the mainstream of the company activity can actually manage risk themselves. In these areas the risk manager helps to identify problems, evaluates potential loss levels, contributes to solutions and is involved in the implementation of the measures ultimately taken to reduce potential financial loss. Management of risk must be an integral part of modern corporate activity".

D.A. Marks(107) believes that "it is management's role to evaluate the risk and to propose a policy to eliminate or reduce it and to keep the risk constantly under review".

The risk management concept, first developed in the United States, it based on the belief that insurance is only one of a number of techniques for the handling of risk. Tony Benson(21) makes it clear that "risk management is a wide field and the identification and evaluation of risk is a difficult business for the industrial company, but if it bears in mind the loss which can follow a given predictable incident, the job is not impossible". He also believes that the corporate risk manager today is "the man who, suitably involved in the earliest planning stages, should contribute to the totality of thinking on matters such as these. Line management in the company should properly involve itself in managing risks, for instance an engineer has a major function as an identifier of risk in connection with existing plant, proposed amendment to it and new projects". Even in terms of evaluation of probabilities in connection with risk, it is likely that the engineer has a leading part to play (Benson). Data is available on the failure rates which can only properly be interpreted by an engineer.

5.4 The Scope of Risk Management

The development of risk management can be seen as part of the more general development of management science; most branches of management have become increasingly more analytical in recent years.

Risk management recognises the interdependence of activities and importance of them to the success of organisations. It employs statistical, analytical, accounting and other techniques to co-ordinate risk control activities and maintain them at optimum efficiency and effectiveness, Keller[93].

Horrigan,[83] who favours an academic approach to the definition of pure and speculative risks and functions of risk management, sees the latter as composed of "identification, measurements and control of risk" and discusses the principal elements of each and looks at the relationship between risk management and profitability.

Caswell and Wilkins[37] trace the broadening of the risk management role in industry from identification, assessment and control of all risk areas to the actions required as a result of social and environmental legislation and the issues of product liability.

Crockford[47] traces the development of risk management and discusses aspects of risk and uncertainty that threaten a business and considers the most appropriate strategy for treating risks (reduction, protection, transfer, financing) to different situations. Fuan and Davis quote[49] definition of risk management objectives and content that "risk management is an aspect of financial management" and give the unusual definition of objectives as being "to maintain as completely intact as possible the cycle of circular flow of funds in business or service organisations".

Jackson[88] defines risk improvement as "the identification of risk areas in every aspect of a company's assets, facilities and operations and improving the situation economically by eliminating, reducing or controlling the risk, together with the preparation of contingency plans to minimise the operational and financial effects of loss and failure".

All businesses are exposed to different risks and it is the responsible management who should identify the directions from which trouble may strike. This requires a detailed study of those companies who have failed because either they did not recognise the threats and risk areas or they ignored them. H.F. Kloman[96] describes risk management as having the following elements: "exposure identification, loss evaluation, loss prevention and control, loss funding, and risk administration". J.V. Davis[49] states that "risk management practitioners need to become skilled in financial management skills. Financial management skills will make the risk management more effective in working with financial superiors in the firm who are becoming more closely identified with the risk manager's function".

5.5 Risk of Failure

Every company is always at risk. The risk exists in every business function with a wide range of possibilities. In the author's opinion a large number of companies failed could have been prevented if adequate monitoring procedures had been introduced together with appreciation or awareness of the risks by management. Awareness can be achieved if there is a good understanding of the weaknesses and risks facing the company. As the business environment becomes more hostile and competitive the chances of failure increase.

Lack of risk consciousness has put many firms in the hands of receivers and liquidators. Therefore risk awareness is an essential prerequisite in success or avoidance of failure. In the present economic climate it is particularly difficult to minimise risk and maximise the chance or survival, however it behoves management to sharpen its ability with regard to threats and risks facing their operations.

5.6 Risk Management Methodology and Company Failure Studies

Risk management methodology can be briefly identified as follows:

1. Identification of threats and risks
2. Evaluation and measurement
3. Prevention and protection
4. Control and solution (elimination, reduction and transfer)

It is interesting to compare these definitions with the scope and concept of company failure, which can generally be defined as:

1. Identification of causes and symptoms of failure
2. Financial analysis and prediction
3. Prevention and control
4. Rescue operations (Re-organisation, Receivership and Liquidation)

The author is of the opinion that the role of the risk manager is one that will become increasingly more challenging and rewarding if he can see the connection between the company failure and risk management.

5.7 Companies Studied

It is important to consider business failure from the point of view of 'fundamental' causes as well as the ways the causes may be evidenced. To achieve this it is necessary to have access to the files, history and background of failed companies to obtain the right information, especially that relating to the structure and organisation of firms.

The selection of companies studied in the present chapter was based on the following requirements:

1. The companies must have passed the early phase of failure which was identified as 'early failure' in Chapter Four of the present study relating to the analysis of time to failure and pattern of company failure. Therefore the companies selected have passed the risks of infant mortality.
2. The companies must have had approved published reports by the official inspectors appointed by the Department of Trade, or special reports by experts.
3. The companies were quoted as a public company.

In work reports by previous researchers there is much confusion between causes and symptoms of failure - in many cases the symptoms being identified as actual causes. Again, these early studies are characterised by a lack of detailed information. It is the belief of the author that the above requirements on selection of companies would obviate the problems. The names of the companies studied and the inspectors or experts are given in the Table overleaf.

Company	Inspectors Appointed by the Department of Trade
Rolls-Royce Ltd	R A MacCrindle QC P Godfrey FCA
Court Line Ltd) Clarksons Holidays Ltd) Halcyon Holidays Ltd)	J P Comyn QC D S Morpeth TD, BCom, FCA J Hamilton MA
Blanes Ltd	D A L Smout MA, LlM B E Basden FCA,
John Willment Automobiles Ltd	P J Millett QC M R Harris FCA
The Vehicle & General Insurance Co. Ltd	T M Eastham QC R T M McPhail MBE, CA
Mitchell Construction*	Simmonds
Bernard Russell Ltd	D A L Smout, MA, LlM B E Basden MA, FCA
Handley Page*	K Cork (Receiver) & Travers
Roadships Ltd (formerly known as Ralph Hilton Transport Services Ltd)	Benet Alan Hytner QC Ian Alexander Noble Irvine FCA

*Handley Page and Mitchell Construction were not investigated by the Department of Trade, but many experts have analysed their failure e.g. Simmonds, Travers, Argenti, etc.

The author's view is that before considering the list of causes and symptoms of failure in large companies it is desirable to obtain the growth and evolution picture of the firms and difficulties encountered in this stage. This provides a guide to understanding where the process of failure starts and why ? In other words it is necessary to understand the behaviour of healthy firms before one can identify the sick one. Behaviour relating to the failed one is then seen to be a deviation from normal growth and evolution. This deviation can arise from an organic defect in the firm and in biological terms is analogous to an individual being born with a physical defect which induces dysfunctional behaviour. Again in the same way that over-indulgence in food, drink, lack of exercise etc. can result in premature death, gross mis-management of a company can cause premature failure.

Before considering the failure characteristics of large companies, it is also important to know the difficulties and general causes of failure in small businesses where the rate of mortality and risk of failure is very high compared with large companies.

5.8 Development of Firms

In a capitalist economy, it can be said that firms may grow for a large number of reasons. A review of the literature offers many reasons. Edward and Townsend (1961) note that "most businesses start small and with pedestrian objectives. Their purpose is to do something similar to what is already being done, and their prospects depend on an expanding demand for their product or on their ability to take some of the custom away from existing firms". (1961, p.4). They add that the most obvious way for a firm to grow is through market penetration and development.

Some authors[153] believe that over the last decade and particularly in the US, there has been a popular misconception that 'growth' of large companies has been achieved by the purchase of other companies in fields unrelated to those of the purchaser. This phenomenon has produced what is often called 'conglomerate' companies - subsidiaries or divisions that have little in common but unified financial management. Shumpeter (1942)[130] puts the emphasis of growth on entrepreneurship. Levitt (1964)[100] points out the importance of this fact by reference to technology, organisation structure and human relations. Nevertheless, companies pass through several stages of growth and development. Barnes and Hershon[15] refer to these stages as "The Company Transition" which are shown in Exhibit 5.1. Buchele (1967)[34] defines growth as a series of crises, while Chandler (1962)[39] referred to this as the result of the company's strategy and structure. Greiner[70] argues: "Historical forces do indeed shape the future growth of organisations". Greiner identifies at least five phases of organisational growth and development. Each phase is characterised by having both 'evolution' and 'revolution'. The term evolution is used to describe periods of growth with relative organisation stability. The term revolution is used to describe periods of "substantial turmoil" in organisation life. Thus as a company moves through developmental phases, each evolutionary period creates its own revolution. The management's solution to each revolutionary period is the deciding factor for the next stage of the company's revolutionary growth.

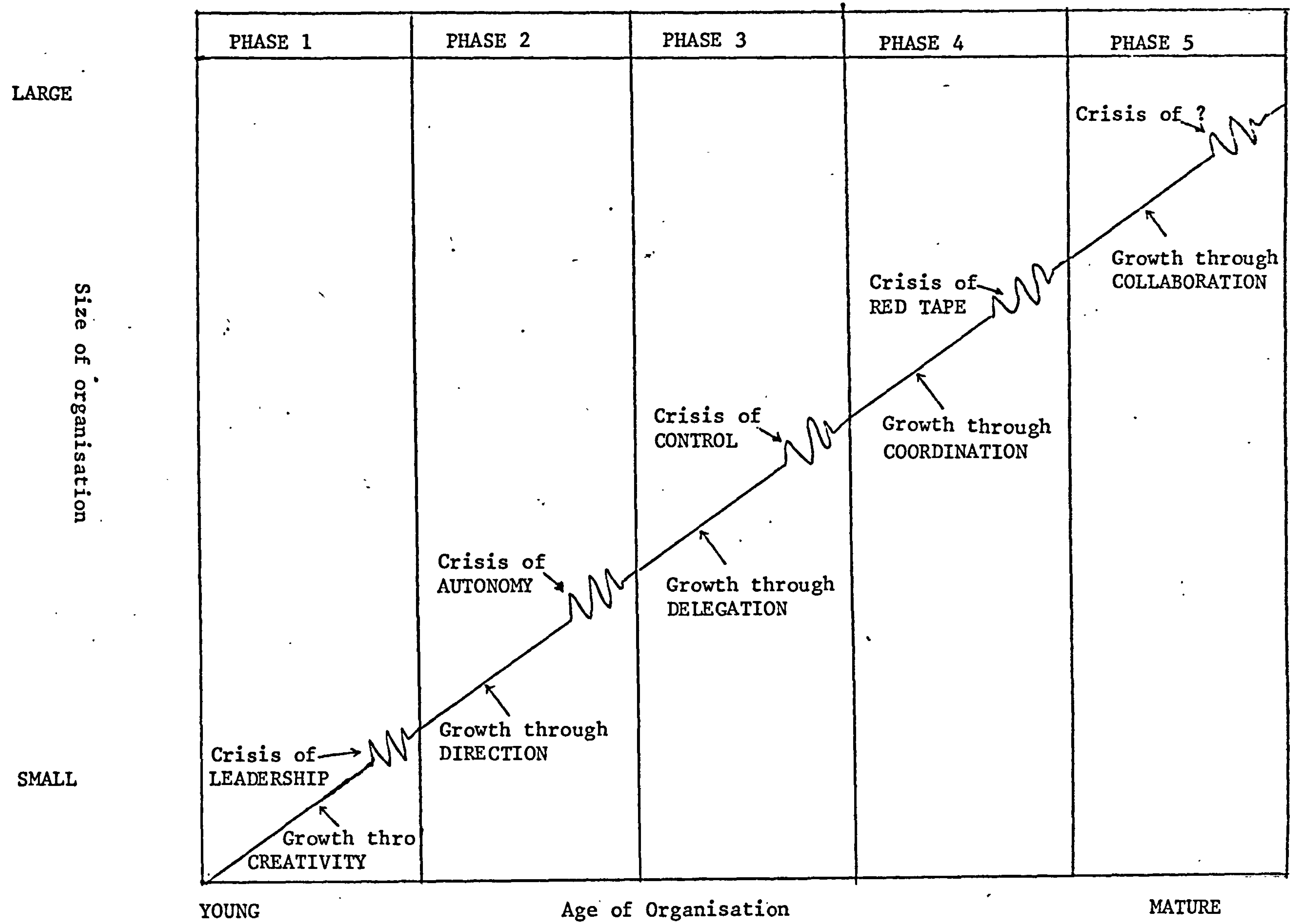
Exhibit 5.2 gives different phases of the company growth. Strauss[143] provides some detail about the nature of growth and survival of companies and suggests the existence of a critical stage undergone by firms as they pass through from 'Youth' to 'Adolescence'. He notes that the point at which this critical point occurs is determined by several factors, among them are:

EXHIBIT 5.1 Characteristics of Company Growth

Organisational Characteristic	Patterns of First Stage	Patterns of Second Stage	Patterns of Third Stage
Core problem	survival	management of growth	managerial control and allocation of resources
Central Function	Fusion of diverse talents and purposes into a unified company	Fission of general authority into specialised functions	Fusion of independent units into an independent union of companies
Control System	Personal (inside) Survival in market place (outside)	Cost centres and policy formulation (inside); growth potential (outside)	Profit centres and abstract performance criteria (inside); capital expansion potential (outside)
Reward and motivation	Ownership, membership in the family	Salary, opportunities and problems of growth	Salary, performance bonus, stock options, peer prestige
Management style	Individualistic; direct management	Integrating specialists, collaborative management	Integrating generalists; collective management
Organisation:			
Structure	Informal	Functional specialists	Division organisations
Primary Task	Direct supervision of employees	Managing specialised managers	Managing generalist managers
Levels of Management	Two	At least three	At least four

Source: Barnes and Herson (1976)

EXHIBIT 5.2 Phases of Company Growth



Source: Greiner (1972, p.41)

1. The ability and personality of its top management
2. The company's production technology
3. The nature of its market
4. The legal status of the firm - a proprietorship, partnership or corporation.

Urrea[153] in a study of evolution and development of the family firms concludes "The most important determinants for the continuity and survival of the family firms were the delegation of authority and the issue of management succession".

Although these authors have not referred specifically to the declining phase of companies and its process, they agree that there are difficulties at the development and evolution stage due to the fact that growth is more than enlargement. The firm changes its proportions as well as its overall dimensions and moves to the point where management must be able to switch a rut-oriented company to a change-oriented one through an analytical and systematic investigation of the details, with self-confidence and imagination in creating viable systems and strategies. Otherwise the company finds itself in a position where the author calls "the beginning of the end" or the starting point of the failure path.

5.9 Small Businesses

Some small businesses get killed, other die through sheer mismanagement, but the fact remains that a good many small firms die prematurely or unnecessarily. The small business sector, according to the Bolton Committee's estimate(27) employ 31% of all employees and its output is one-fifth of GNP - facts which make it clear that small firm operation forms a very important part of the economy. In its Conclusions, the Committee stressed that the small firm is in many ways a highly efficient organism, better adapted to exploiting certain kinds of economic opportunity than larger units, and with special advantages of intense commitment of the owner-manager. Walsh believes that the theoretical potential of small businesses for growth is in many cases not being realised. There are three main reasons for preferring to remain small - lack of managerial capacity, inadequate rewards and loss of the personal touch.

Rosemary Brown(33) quotes that "the fact is that over the last two decades, the small business sector has been in consistent decline. This is not a uniquely British phenomenon; the same has been happening in Germany, France, Japan and North America".

The law of today's industrial jungle is the survival of the biggest. Hypermarkets are replacing supermarkets, the multinationals are in full strength, and the current understanding of economies of scale implies international co-operation. Small should not be confused with mini. The definition of a small firm, as given by the Bolton Report, is in general terms one that employs less than 200 people, although there are various qualifications. The three characteristics that Bolton sees as typical of the small firms are:

1. It is managed by its owner or part-owners in a personalised way.
2. It has a relatively small share of the total market.

3. It is independent, in that it does not form part of a larger enterprise and itw owner-manager is free from outside control in taking their principal decisions.

Failure in small businesses

The threat of failure confronts many small business enterprises, particularly those that are newcomers. The high mortality rate of young companies indicates that small firms are the primary victims.

As was stated in Chapter Three, the author found that 28.8% of all failures in manufacturing industry in England and Wales occur in the first three years and 47.3% in the first five years of their life. The figures for America are nearly the same. Dun and Bradstreet statistics of business failure shows that 53.2% of companies were 5 years, or less, old. Broom et al quote that in view of the obviously limited resources and lack of financial stability on the part of many small firms, it seems probable that small business mortality is greater than big business mortality; over 78% of the failures occurred in firms having less than $100,000 in liabilities. The most significant causes of small business failure were given as: lack of skill in management, competition, lack of capital, location, premature expansion. They also believe that the following types of changes are symptoms of impending business failure:

1. Deterioration of working capital position
2. Declining sales
3. Declining profits (or increasing losses)
4. Progressively higher debt ratios.

Spooner[139] who chaired a discussion of a team of specialists to find the real answers to small company problems, summarises their findings as follows:

a. Management Myopia: This is one of the biggest threats to the small firms and one of the biggest obstacles to overcome in planning a survival programme. This is partly a belief that insolvency, like accidental death, is something that happens to the other chap, and partly a refusal to accept that past successes may not provide a formula for surviving the rough-and-tumble of business today.

b. Too much reliance on flexibility: The second point emerged is that because a small business relies so much on flexibility - its ability to react facter than big companies - corporate planning of any kind is considered as a dangerous constraint; the result being that too little attention is given to planning and anticipation of areas to which they will be unable to meet.

c. Cash and profit: Any survival plan has to be conceived in two parts: short-term and long-term. The first is concerned with cash, the second with profit. Weaknesses in this area are frequently caused by the small firm's difficulty in recruiting (let alone retaining) someone with sufficient expertise to take the role if not the name of finance director.

d. Gearing problems: Many small firms often run into trouble because they under-estimate what inflation has done to their demand for working capital.

e. Control: Small firms are traditionallty anti-planning because they fear that committing themselves to a specific course of action will cramp their style. The choice of controls is largely governed by the nature of the business.

Bolton's comment on small firms is that the economic climate in which they are operating, with high inflation causing severe cash shortage, higher taxation and the increased burden of government legislation, combined with poor trading conditions has led to a record rate of bankruptcies and receiverships among small firms. The obvious limits on resources - financial and human, the high costs of up-to-date technology, and the increasing rate of product and service obsolescence make the management of smaller businesses far more difficult than the management of giants.

5.10 Rolls Royce Ltd

5.10.1 Background

Although Rolls Royce was incorporated on the 15th March 1906, with an authorised share capital of £60,000 the foundations had already been laid in Spring 1904 when the Hon. C S Rolls travelled to Manchester to meet Henry Royce.

In the few years before the outbreak of the First World War, the Rolls Royce Silver Ghost became established as a high quality car. Shortly after the outbreak of war in 1914 Henry Royce began to design his first aero-engine as a private venture, having failed to persuade his fellow directors to enter the field of aviation. After 1918, the production of this engine continued on a reduced scale.

In 1931, the Bentley Motor Car Company which was in financial difficulties was acquired by Rolls Royce. In 1938, Rolls Royce acquired Park, Ward and Company, a firm of coachbuilders. In 1943, the Ministry of Aircraft Production asked Rolls Royce to take over from the Rover Company Ltd the control, as managers and agents of this Ministry, of a shadow factory at Barnoldswick where the development of the Whittle W2B engine was taking place. At the end of the Second World War the company was developing its own design of jet engines.

In the years from 1951 to 1966 Rolls Royce developed and put into service turboprop and turbojet engines for both military and civil purposes. In 1957 Sentinel (Shrewsbury) Ltd was acquired to enlarge the capacity for the production of oil engines. Another coachbuilder, H J Mulliner, was acquired by Rolls Royce in 1959.

Bristol Siddeley Engines Ltd was another acquisition in 1966; this company at that time was developing the Pegasus engine for the Harrier aircraft and jointly with SNECMA (a French aero-engine manufacturer), the Olympus 593 for the Concorde.

Extension of activities and entering into the nuclear engineering field through 'Rolls Royce and Associates Ltd', the manufacture of rocket motors and use of computers for management purposes, are other stages of the company's history.

A significant stage of Rolls Royce history started in March 1968 when a contract was signed with the Lockheed Aircraft Corporation for the construction and delivery by Rolls Royce of an advanced technology engine designated the RB211-22. The contractial obligations entered into by Rolls Royce were formidable. The RB211-22 was the largest engine that Rolls Royce had ever undertaken. Ultimately it was expected to develop some 42,000 lb thrust, which may be compared with the 21,800 lb thrust developed by Conway, the largest Rolls Royce engine which had as yet entered service.

This contract was greeted with enthusiasm throughout the country, and certainly this major breakthrough into the US market, for such it was, represented one of the largest single export orders ever obtained by a UK concern.

These events were accompanied by a financial growth of the company to a point where in 'The Times 500' of 1969/70 Rolls Royce was listed as the 22nd largest industrial company in the UK. However, the continued developments of civil aircraft engines without substantial supporting military contracts placed a severe strain on the financial resources of the company.

Partnership with a US company, the Allison Division of General Motors

Corporation and collaboration with other European aero-engine manufacturers are amongst other different projects undertaken by Rolls Royce.

By 1970 technological difficulties experiencedd with the RB211 development programme were causing severe financial problems and a trading loss for the half year to June 1970 resulted. The ever-increasing financial requirements for the completion of RB211 which had reached to more than £100 million and delay or postponement of the project put the company and its advisers into a situation to conclude reluctantly that it could not properly continue, and finally on 4 February 1971 Rolls Royce appointed a Receiver.

The White Paper "Rolls Royce Ltd and the RB211 Aero Engine" records: "Rolls Royce's liabilities were large, hurriedly estimated, in part unquantified and unquantifiable, No great reliance could be placed on the company's estimates which had been prepared hurriedly. In the end Ministers considered that whether the RB211 project was stopped or continued, it would not be a responsible use of public funds to assume a very large unquantified commitment either by supporting the company with funds which it had no prospect of repaying or by the Government taking the company over and thereby making itself responsible for all the company's debts and obligations".

On 4 February 1971, Rolls Royce was clearly insolvent because:

a. It was unable to pay its debts as they fell due.

b. The future cash requirements were £107 million in excess of the £70 million borrowing facilities normally available to it.

c. The losses of resources committed to the RB211-22 project, combined with the liability for damages which might arise in connection with the delay in delivery of the engine, were likely to exceed the net tangible assets of the company.

This was the end of the road for Rolls Royce, the company which according to inspectors and most of the people was not lacking in skilled engineers, it was not lacking in aero-engine experience, it was not lacking in advice from outside advisers and consultants of the highest repute, it was not even lacking the confidence of its bankers and Her Majesty's Government. Rolls Royce was never short of brainpower, or even individually competent managers. What it lacked was an adequate, proper and right management system needed to combine that brainpower into a strong, wealth-creating organisation.

5.10.2 Causes and Symptoms of Failure

Board and Management Structure

Rolls Royce's Article of Association which was amended in July 1958 states:

"That divisional boards be created with effect from 23 July 1958 for the management and carrying on the business of the company's Aero Engine Division, Motor Car Division, Oil Engine Division, and International Division respectively, and that the same be herebu constituted. ....."

This amendment permitted the creation of Divisional Boards. The International Division was disbanded in 1964 with its activities merged with those of manufacturing divisions and in part became the responsibility of the company Commercial Director.

Following the acquisition of Bristol Siddeley its activites were reorganised into six divisions. In September 1967 according to the reviewed regulations, the divisional boards were to accept basic responsibility for the management, capital expenditure and financial results of those minor subsidiary and associated companies which were primarily concerned with the business of that division.

The divisional boards were responsible to the main board through the divisional managing director. In some cases members of the main board were members of a divisional board, in other cases a main board director was responsible for affairs of a division.

The composition of the board was in numerical terms between 14 and 16 directors during the period 1967-71, of these, 10 were full time executive and the rest non-executive directors.

"In terms of the background, two of them were finance men as financial directors and the other eight directors were basically engineers by training and experience from service with Rolls Royce. The non-executive directors were bankers or distinctive businessmen".

The working of Derby Engine Division (DED) was of particular importance. Its board was dominated by engineers. The information placed before it took the pattern of the main board papers. This board, according to the Official Report, was not "the effective body through which the real management processes of the division were carried out. Several witnesses have testified to the effect that as a management forum for decision taking, it was ineffective which was partly due to the unwieldy size of the board - in 1969 it numbered 22 members of whom only one was not an engineer !"

In truth, management of the division rested primarily with Sir David Huddie, its managing director. For this reason it suffered from the lack of a strong helmsman when Sir David found that the RB211 project required him to be out of the UK, and when his physical well-being began to deteriorate."

The organisational structure consisted of five autonomous functional departments. Just as the main board eventually saw the value of a finance committee, so did DED and in May 1970 a divisional finance committee was formed.

Finally in the management structure of Rolls Royce, it was perhaps unfortunate that the chairman and chief executive functions were in the hands of one man. The weaknesses of management structure and board can be summarised as:

1. Unbalanced board with a domination of engineers.
2. Ineffective divisional structure and organisation.
3. Poor communication and information system, due to lack of proper consideration to different areas.
4. Too mush authority and reliance on one man.
5. Poor value system for selection of board members.

Risk and Uncertainty Surrounding the Industry

One of the main points made in the Plowden report, which considered the development of the aircraft industry, is that: "Aircraft manufacture has always been, and is likely to remain, an uncertain business. It will never be possible to make a simple and straightforward plan and by pursuing it doggedly, guarantee success."

The risk associated with aero-engine manufacture in general and Rolls Royce in particular can be broadly categorised as:

a. Production risks
b. Research and development risks
c. Dependence on one large buyer risk (dependence on government)
d. Market risks
e. Industry risk

The most significant problem is that of uncertainty or unpredictability in respect of future technological developments, their feasibility, the difficulties to be overcome and the associated costs. The difficulties are compounded according to the degree of advance beyond proven technology. The more a project involves entering the higher reaches of unproven technology, the more the difficulties are multiplied. To take work of this nature to a successful outcome should normally be undertaken only by a company on terms where the cost exposure of that company is appropriately limited or underwritten e.g. on a 'cost plus' development contract basis. The undertaking of projects in Rolls Royce, especially the RB211, when the company was already in an uncertain financial situation, was based on basically fixed price terms with limited launching aid from Her Majesty's Government. This placed the company at risk or as official reports say, "An open-ended commitment which was a speculation rather than ordinary commercial risk". Other reason of speculation of this project is when investment in the project is relatively high in relation to the net worth of the company, and dependence on its success vital.

"Another problem for Rolls Royce management was the problems of uncertainty and unpredictability in relation to future development turnover and work load".

Also there was a risk due to overspending and inefficient use of resources of other projects if there was a delay in the completion of the project.

Finally, the board as a whole did not appreciate fully the extent of the risks involved and failed to produce the objective analysis of the risks involved. They accepted the rash commitment of a risky and uncertain investment.

The Chairman of Rolls Royce accepts in an interview with inspectors that the board did not sufficiently examine at the time neither the risks nor the consequences which would arise should the company's projections turn out to be wrong.

There is no doubt that few businesses are wholly without risk, but the size of the risk and the consequences of failure should always be adequately considered before an entire business is jeopardised, but these were not adequately probed. The whole structure of the company was hazarded on one contract. It is not always wrong for a business to put all its eggs in one basket, nor is it always wrong for a business to undertake a speculative project, but Rolls Royce combined these two and invited disaster.

Occasional Change of Accounting Policy Concerning the Treatment of Research and Development Expenditure

By altering the treatment of the R & D expenditure and acceptance of new accounting presentation, Rolls Royce intended to show profits which would justify continuing their dividend distribution. As the inspectors quote, "This was of vital importance, because any reduction in their profits or dividend meant immediate restriction of their ability to broaden their business in any way which required either raising fresh money or the acquisition of some other business".

The effect of these accounting policies on the reported profit for the nine years to 1969 compared with those which would have been reported had the company continued to write off as incurred all Research and Development expenditure is shown in the following Table.

	Profit (loss) after taxation		Dividend	Transfer to (from) retained profit	
	As reported £M	After writing off R & D as incurred £M	£M	As reported	After writing off R & D
1961	2.5	(1.7)	1	1.5	(2.7)
1962	1.7	0.6	0.7	1.0	(0.1)
1963	4.0	5.4	1.2	2.8	4.2
1964	3.6	4.7	1.5	2.1	3.2
1965	4.5	4.4	1.6	2.9	2.8
1966	5.3	5.3	3.7	1.6	1.6
1967	7.5	5.2	6.1	1.4	(0.9)
1968	8.8	4.6	7.3	1.5	(2.7)
*1969	4.3	2.0	4.0	0.3	(2.0)

*Before special provision £11 million

Dependence on Borrowed Money

The proportion of borrowed money by Rolls Royce in different years is set out in the following Table:

Year	% Financed by Borrowed Money
1961	46
1962	51
1963	41
1964	33
1965	38
1966	49
1967	50
1968	44
1969	45

This Table clearly indicates the dependency of Rolls Royce on borrowed money to finance its business.

Defects in Financial Control

The inspectors' report on financial control indicates that "the machinery of financial control in the company had a good many defects. The personalities on the financial side were out-gunned and out-numbered by those on the engineering side".

The evident deficiencies in financial control of the company were:

a. Lack of any standard form of submitting reports

b. Lack of financial control organisation. The clear sign was, the diverse manner in which different divisions reported to the main board and the company financial director.

c. Inadequate financial controller's staff

d. Poor presentation of variances in standard costing sense. Variances were never expressed in percentage terms to hindsight their significance. The narrative explanations of adverse and unsatisfactory figures were minimal and did not explain the root causes.

e. Voluminous, out of date and inconsistent information to the board.

f. Lack of board's consideration of financial information. The financial information was optional rather than compulsory reading and the board's consideration of this information occupied vert little of its time.

g. Poor forecasts.

h. Different costing systems

k. Poor product profit plans.

Although the inspectors came to the conclusion that at the end of the day, however, the appointment of a receiver was not caused by a defective system of accounting, reporting or forecasting, it should bear in mind that failure is not a sudden process, and as it takes time to happen, therefore each of the defects could have had some contribution to the final collapse of the company.

Financial Causes

The contract with Lockheed provided that for engines delivered up to 31 December 1971 there was to be a specified fixed price, therefore Rolls Royce was to carry the risk of cost and wage inflation in that period.

Underestimation and Optimistic Forecasts based on Previous Success

Too much confidence on estimates of previous projects, especially SPEY, which turned out to be so reliable was a source of misplaced accuracy. As one of the main board members says, "We launched the SPEY engine in about

1962 with its various marks in subsequent years and we forecast that the launching cost of that engine would be £30 million approximately. When the end of the day came, we had spent £30 million approximately. It was quite remarkable. The RB211 is what we call a three-shaft engine.Up to the stage when it was abandoned, everything about that engine had been absolutely right; it undoubtedly gave a great deal of overconfidence".

The reliable estimates of SPEY was in part due to the experience gained in the Conway and Medway engines, but in the case of the RB211 comparable experience was not available, and it was not therefore reasonable to expect the same stabdard of reliability in the estimates.

The larger the proposed technological steps, the larger the probability of overspend and the further forward projections are made, the less reliable they become.

Too Ambitious Project

The design of the RB211-22 engine incorporated major advances beyond the company's existing technological frontiers. The step forward in technology that Rolls Royce was proposing to take was too big.

There was too much enthusiasm and ambition without proper consideration of risks, uncertainties and market and partly a gap between marketing and production. Commitment to develop, produce and deliver the RB211 project to a fixed time scale and at a basically fixed price, was another contributory factor in delay, increasing difficulties and financial problems of the company.

Poor Acquisition

Lack of proper study of acquisition proposals in the case of Bristol Siddeley, especially the financial figures, was a weakness. Although this acquisition and the burdens it imposed on Rolls Royce were not, according to many people. Causative of later crash, nevertheless this was something of a 'shot-gun wedding' and did nothing to strengthen Rolls Royce.

The author is of the opinion that as the failure is a long term process and it happens gradually, therefore one must accept the financial problems raised by the acquisition and its effect on borrowing money and future decisions that the company took.

Inadequate Attention to Other Works and Projects

Too much attention to a big project always brings less consideration of previous or other projects in progress, which, in some cases, can give more support or help to the development of the big project. For instance, the continuance of the RB178 demonstrator programme, which was terminated for mainly financial reasons, would have helped considerably with the development of the RB211 engine. This is due to the weaknesses of project management and the effect of undertaking an ambitious project at a time when the prestige and survival of a company is at stake. The author believes this is a symptom rather than a cause.

Technical Problems

Four major technical problems were:

1. The RB211-22 was the first civil project to be undertaken after the re-organisation of the engineering department and the creation of project groups, which did not allocate the invaluable experience of senior design personnel to the RB211, especially in the early, critical stage of the design.
2. Too much involvement and commitment of different divisions, when Rolls Royce was taking the Lockheed contract.
3. Inexperienced and insufficient staff to cope with the sudden influx

of work, for example in the development of the RB211-22.

4. The death of a dynamic leader and brilliant engineer (Mr A Lombard) in July 1967.

Chairman's False Statements.

In the Chairman's Statement of 22 June 1970, shareholders had been told that the board was satisfied that the company had sufficient working capital, though estimates by then available forecast showed a substantial cash shortage. The word 'satisfied' was in the circumstances a misleading and unfortunate one..

5.10.3 Summary of Causes of Rolls Royce's Failure

1. Too much dependence on a single customer and project.
2. An inadequate management information system.
3. Too much reliance on previous success and ability
4. Lack of appreciation of risks and uncertainty involved in industry and undertaking an ambitious project.
5. Weak board of directors with a poor composition of balanced skills and management ability.
6. The gap between marketing and production.
7. Over-running of cost and time due to poor estimation.
8. Lack of standard accounting systems.
9. Ineffective divisional boards (DEB)
10. Failure in investment strategy, i.e. the changing pattern of activities from military and government sector to private contracts.

5.10.4 Summary of Symptoms

1. Voluminous reports to the board.
2. Lack of consideration of financial reports sent to the board
3. Out of date information; accounting manipulation
4. Too much dependence on borrowed money (gearing)
5. Too much reliance on a single project and customer
6. Technical problems and stoppages of projects.
7. Poor estimates and forecasts
8. Increasing difficulties in changing the designs
9. Increasing costs of development stage
10. Financial problems, liquidity difficulties
11. Too much dependence on the engineering side
12. Lack of adequate finance personnel
13. Unbalanced attention to different projects
14. Lack of direction by board
15. Chief executive and chairman responsibility for one man
16. Poor communication
17. Overspending
18. Ratio of $\frac{\text{Actual cost}}{\text{Initial Estimates}}$ too high.
19. Delays in project completion date and delivery of engines

5.11 Mitchell Construction

5.11.1 Background

Mitchell Construction was one of the construction industry's few glamour shares, much favoured by experts for its seeming financial acumen. As Simmonds[131] quotes: "This is a story of determination, company loyalty, competitive edge and sensible accounting. Its fall is a sobering illustration of how even such qualities as these can go badly awry. It is the abrupt demise of a vigorous and successful £40 million a year company".

The company had until January 1973 an almost unimpeachable growth record. At the time of crash it left behind unfulfilled home-based contracts worth over £24 million. Mitchell had plenty of work overseas with activities in the Caribbean, South Africa, Portugal, Canada, Holland and Germany. At one time it held the world hard rock tunnelling record.

It was on January 31 1973 that the Chairman and founder of the company conceded that the position of the company had become untenable and asked for a receiver to be brought in. The debts of the Mitchell Construction Kinnear Moodie Group at the time have been put at some £6.5 million. The losses sprang from two distinct quarters, the first was the losses incurred and continuing on the group's largest and most spectacular contract of all - the Kariba Power Station in Zambia, work on which started in 1971. The second was due to delayed payments to the company on some 20 UK contracts in the public sector.

5.11.2 Causes and Symptoms

1. Lack of proper risk analysis

There was no appreciation of risks associated with a spectacular project such as the Kariba Power Station. This always happens when a company is already in trouble and when they went to buttress them the only alternative left (and in reality the worst) is a big and spectacular contract or project which is lacking a proper study of resources available, feasibility and risks and uncertainties involved.

In 1970 this mistake committed Mitchell Construction, already in some trouble, to the power station contract. This happened when the company decided to go alone after its joint tenderer Burton Construction failed to obtain the necessary bond as guarantee. This decision to go alone was to invite more risk and earlier disaster.

Another aspect of the risk associated was stated indirectly in the 1969 Chairman's annual report where it says that "the Zambian company was being closed down because of the effect of political tensions on British companies".

Lack of experience of executing large isolated contracts in Africa was a gamble and another risk which was not adequately appreciated.

Finally, a massive differential in company's tender of £11 million plus with other bidder which was nearly £2 million, while the company did not have skill or experience advantage.

<u>External Factors</u>

Rock falls in 1970 killed two men and brought part of the site to a standstill, and the employer failed to provide access roads and accommodation. Also the site of the underground machine hall was moved by the designers which again caused disruption.

<u>Poor Relations with Consulting Engineers</u>

Although the company had maintained good relations with the old Ministry of Buildings, its relations with consulting engineers which were vital links in the chain, were hostile.

<u>Delayed Payments</u>

Mitchell Construction's emphasis on public projects and the public sector was not successful. There was a time when the company did have a staggering figure of £11 million outstanding on some 20 UK contracts for public and government authorities. Delayed payments was a prevalent problem in the public sector.

It is of considerable importance to know that, as Simmonds(131) writes, "construction is one of a minority group of industries in which work is paid for in instalments. Contractors are normally paid monthly on the basis of a measurement of the work completed, less certain retentions. In this way working capital can be kept to a minimum - an important factor contributing to the high birth rate and rapid early growth of construction companies. If payments are inadequate or delayed for any reason, the cost of financing a contract can easily be increased by many times over the amount allowed for, creating liquidity problems." This is not a cause, but a sign of bad financial policy and control in Mitchell Construction, which was a contributory factor to the financial difficulties and collapse of the company. This is further evident when one considers the three categories of payment to contractors in construction and civil engineering, which are:

1. Interim payments as the work proceeds
2. Final payments for the contracted work
3. Additional payment on account of variations.

<u>Value System</u>

"Annual reports after annual reports listed new appointment but the sad result was that towards the end there was a chronic lack of experienced site staff, because the encouraged young managers had all been promoted ti higher jobs which they were not yet fully equipped to do".

There was a complete lack of a system for promotion and succession, Even if there were systems and procedures, their use was wrong. As a consequence, the top managers were pulled downwards into minor affairs, dealing with clients on site, where they had no business to do.

The sign of a poor value system is the lack of a balanced team. "The group was being run less by managers than by technologists and engineers".

Centralisation (Lack of Identity)

The organisational structure of the group which was based on centralisation, had given considerable agitation to move Mitchell Construction away from group headquarters in order to give it a separate identity and leave the group organisation, but unfortunately the construction company was such an integral part of the group organisation at Peterborough that to remove it would have left a completely unviable entity.

There were suggestions, had Mitchell disentangled itself from the group and functioned in a similar manner to other operating companies, separate liquidation might have been possible. The centralisation was not only organisational, it was also geographical.

The reason for geographical centralisation was to rely on services provided from group headquarters at Peterborough.

Failure to set up a proper organisation meant unaccessibility of the company to a vast market of medium-sized and smaller contracts, due to inability to compete with local firms. The centralised organisation of the company with its communications system added to the problems and costs of managing even other contracts in the region.

Lack of Strong Sales and Marketing Organisations

Mitchell Construction never found any suitable substitute for hydro-electric and CEGB work when these contracts dried up. The sudden slow-down in CEGB work in 1968 was a severe blow, since at this time the company was lacking a strong sales and marketing organisation to seek new opportunities, which was, to a large degree, because of its preference for the competitive rather than negotiated contract.

Lack of Response to Competition and Change

Mitchell followed its individuality, even though the large schemes had run out. It did not quickly respond to the changes that its rival firms showed, for instance it was slow in the area of property development which had proved to be vital for construction companies.

The group was also much behind its competitors to combine in consortia to carry out ventures which they could not manage on their own. The group's response to change was not on time and this was one of the major weaknesses and causes of collapse. Mitchell Construction which was run by one man in nearly 15 years, climbed from an obscure engineering company to an international group, buts its response to change was poor and too late.

There was no succession policy in replacing the founder who withdrew from day-to-day running of the company. The top management needed reorganisation; the whole organisation needed a complete change. Diversification into more promising fields would have helped the company when it needed bases of earnings. The changes were not properly recognised, even when they were identified there was resistance to them which was due to being too proud of earlier success and expectation that, because the business had gone so well in the past it would somehow or other continue to do so in the future.

The group failed to develop an organisational structure, led by top management, with a framework within which steps necessary to maintain the company's viability could have been taken. Without fundamental changes, it was only a matter of time before the company failed.

Finance

In Mitchell Construction one can briefly describe the financial problems as adequate procedures inadequately followed up. There was too much paperwork for contracts and lack of corrective actions.

One Man Idea

The founder of the group had the credit of developing a small company into an international group. He had qualities of strength and determination but the system in the group was not flexible enough to replace him adequately.

It is said that part of the group's trouble was the strength of the man who made the company. Strong leaders, according to some opinions, will never relinquish control sufficiently to give top managers complete freedom. In Mitchell Construction, the leader had to keep firm hold of the reins because nobody else, as was to be expected, had qualities of srength and determination in the same measure.

5.11.3 Conclusion

The significant causes of collapse in this company were:

1. Lack of response to change
2. Value system (management structure)
3. One man idea
4. Project failure
5. Too much dependance on big customers
6. External Factors
7. Poor policies
8. Ineffective organisation

5.11.4 Symptoms

1. Losses due to financial difficultues of Kariba project which reached £2.5 million and was continuing at a rate of more than £200,000 a month.
2. Adverse report from Kariba project in the city.
3. Declining pattern of share prices. The company's share price in 1971 had

been sliding continuously and steadily. Publication of 1971 Accounts for half-time gave a loss of 50p overnight.

4. Accounting results. This is a by-product of decisions taken to cover the company's weaknesses and a product of accounting manipulation to give a better appearance to the balance sheet. 1971's full year's account which showed an amazing profit of £1 million (taking into account the half-yearly account) not only did nothing to remove suspicions, but it served to increase the fear.
5. Too many meetings. One of the directors attended 146 meetings in one year.
6. Depressing atmosphere
7. New appointments
8. Reducing numbers of experienced personnel
9. Extensive paperwork.

5.12 Roadships Ltd (formerly known as Ralph Hilton Transport Services Ltd).

5.12.1 Background

The story of this company starts with a quick review of its founder's background, who was born in 1923 and in 1954 he bought a lorry and drove this for profit while he was an assistant in his father's public house. In 1956 he purchased a petrol filling station and workshop and gradually built up a small fleet of lorries. By 1959 he acquired depots in Clapham, Greenwich and Vauxhall and his fleet rose to 49 vehicles.

By this time the turnover of the business was £69,000. Hilton accepted his then auditors to form a limited liquidity company which was duly formed but the real weakness and threat started from this point, as he continued to run the business on the same lines as if he was the sole proprietor of his firm. From 1961 the expansion of the company was by means of acquiring other small transport businesses. By the end of 1968 the vehicle fleet had risen to 400 vehicles and the turnover for the first time exceeded £1 million with activities of shipping and forwarding, a Customs & Excise approved warehouse, the manufacture of tarpaulins, insurance, security and road transport.

During 1968-1970 Hilton Transport Services Ltd (HTS) acquired companies of larger size with the total investment of £568,000. The important point was that none of these businesses was particularly profitable at the time of acquisition. The object was to acquire transport depots with a sufficient nucleus of existing customers to make possible an expansion of the transport business out of London. In these two years HTS built up its regional transport services with trade concentrated on the short and medium hauls.

William Joy Ltd and W Reeves & Sons Ltd were of particular interest to the acquisitions of the company. During 1969-70 the company achieved a substantial growth in its warehousing and distribution business. The commitment of capital forced the company to go public when the prospect of a successful flotation was not as bright as might have been desired.

The common feature of most of the early acquisitions was unprofitability, unsued tax losses and all were acquired for cash. In many cases goodwill had been over-valued. Ralph Hilton Transport Services Ltd (HTS) was a publicly quoted company. Hilton Transport Services changed its name on the 16th September 1974 to Roadships Ltd and on the 6th June 1975 Roadships was placed in the hands of a receiver and manager.

5.12.2 Causes and Symptoms

1. Board of Directors

During 1962 to 1967 the company was run in all respects as Hilton's firm. Between 1967 and November 1970 the board never functioned as such and that,window dressing apart, the company continued to be run as a proprietary firm. There was conflict between Hilton and others relating to the frequency of board meetings. Every lunchtime a number of directors and employees assembled in the directors' canteen.

There were signs of an autocracy in the board and company, as one of the directors describes the atmosphere as "like Gestapo headquarters", we find a trifle hyperbolic but we do accept that if any director or employee had made a determined effort to stand up to him, his life would have been nasty, brutish and short.

The Chairman and Managing Director post was held by one man which does not seem correct in a public company.

Inability of the board was also the major reason to decide to be floated as a public company.

Management Problems

The Hilton Transport Ltd management problems caused by many factors,"but mainly it was brought about by the autocrat chairman with a rough and tough business nature".

Inexpert and inexperienced management of the warehousing sector clearly contributed to the losses, as inspectors point out "There was reckless and ill-thought programme of expansion without a proper management information, costings and control system". The autocracy did not permit a balanced or participative board in the company. He ignored the recommendations by other directors; "he had divested himself of real advice at board level and after summer 1970, he was so misled about the true trading performance of the company. He was never adequately advised of the chaos in the accounts department. The personal style of management was wrong."

Lack of Proper Acquisition Policy and Strategy

There were unjustified acquisitions and mergers based on the claims that management would be strengthened by the merger. There were also unjustified claims that the merger would result in combined financial resources which would put the new group in a stronger position to consolidate for further expansion. The acquisition of the companies from British Oxygen Co. Ltd was a serious mistake.. The merger with J & H was also a serious mistake with serious adverse consequences. The main reasons for poor acquisitions and mergers were:

a. Lack of clear strategy
b. Irresponsibility of the board
c. Autocracy of the chairman
d. Lack of working capital and acquisitions with borrowed money.
e. Lack of management ability.
f. Irresponsibility of finance company.
g. Lack of skill and care.

The company was finally trapped by a continuing depression in the industry, whilst committed to a very substantial expansion programme.

Cash Problems

Inadequate cash planning has contributed to the serious financial position of the company. By February 1972 the company was faced with the serious problems of under-capitalisation of its equipment. The cash crisis was briefly caused by:

a. Costly expansions and over-expansions

b. Capital spending

c. Lack of control over business

d. Profit shortfall

e. Downturn in transport business

f. Unprofitable enterprises

g. Misfeasance

Misleading Reports, Accounts and Statements

The results of Hilton Transport Services for the half-year to 31 January 1971 announced with £244,000 profit before taxation were considerably overstated, the overstatement being not much less than £106,000. This was due to fraud and lack of skill and care of the company accountant, the state of the accounts department and lack of board responsibility. Also, the results of HTS to 31 July 1971 as £500,000 were overstated, in the region of £299,000. The circular to shareholders relating to Bain and Hodge was misleading. Whilst the company did not have a sufficient working capital, the circular claimed that the company could meet existing requirements. Another circular to shareholders dated 16 June 1972 was misleading in stating unjustifiable optimistic forecast of company's trading profit.

The Chairman's report for the year ended 29th July 1972 was misleading with unjustifiable optimistic forecast of the company's trading position.

The major factors in misleading statements were:

a. Lack of an able and responsible board

b. Poor management and information system

c. Lack of skill and care

d. Errors of judgement

e. The Chairman's autocracy and the pressure he put upon others.

f. Fraud.

Poor Communication

There was a shortcoming in information required by the board to enable the formulation of policies. The information system and control in this company was in deteriorating state due to management style, lack of ability of the board and autocracy. Even the accounts department, which had never been adequate, dramatically deteriorated after July 1971. The most significant sign of poor communication was the disarray in accounts and other departments, which led to misleading reports, errors and poor acquisition decisions. The board did not take any effective steps to ensure that it was supplied with detailed financial and management information on a regular basis.

5.12.3 Conclusion

According to official report by Benet Alan Hytmer, QC and Ian Alexander Noble Irvine, FCA, the collapse of Hilton Transport Services Ltd resulting in the appointment of a Receiver and Manager on 6th June 1975, was ultimately due to "weaknesses in the company which existed at the date of flotation and which, not having been remedied by the time of the merger with J & H rendered the collapse of HTS inevitable."

If we want to classify the most significant causes of HTS' failure, the following order can provide a reasonable picture.

1. Lack of proper study before going public.
2. Lack of a formal and clear expansion strategy
3. The ineffective board with an autocrat on top
4. Lack of appreciation of duties and responsibilities of a public company by directors
5. Lack of an effective information and control system.
6. Poor management structure and system
7. Inadequate management accounting system

5.13 The Vehicle and General Insurance Company Limited

5.13.1 Background

Vehicle and General, which is referred to as V & G or the company in this analysis, was incorporated on 10th September 1923 for the purpose of insuring bicycles. By 1959 this business had almost ceased. About this time the then controlling shareholders disposed of their shares in V & G and it was suggested to Mr Reginald Ivor Buur and his accountant adviser, that V & G might form the basis of an investment company to be run in conjunction with an existing finance company of which they were directors and in which they had shareholdings - Liverpool and County Discount Co. Ltd.

On 9th January 1961 V & G held a board meeting and the existing directors, secretary and auditors resigned, and on 13th January 1961 new directors were appointed. The company now had a paid-up share capital of £50,000 which, in accordance with the requirements of the Insurance Companies Act, 1958, enabled it to undertake all insurance business, the new owners and management were installed and motor underwriting commenced.

The premium income of V & G grew rapidly during early and mid 1960s. The expansion of the company was based on acquisition and formation of subsidiaries. In 1962 Automobile and General Insurance Co. Ltd (A & G) was formed as a wholly owned subsidiary for the purpose of insurance of drivers with reasonable no claim records. In the same year Andrew and Booth Ltd which was an insurance broking concern was acquired. This acquisition followed with acquiring numerous small companies operating in the same field to secure a tied market.

In March 1963 Occidental Life Insurance Company Ltd was registered in England and in 1965 this company became a wholly owned subsidiary of V & G with changing its name to Life, Casualty and General Insurance Co. Ltd (LCG).

Another wholly owned subsidiary was formed in March 1974 for the insurance of commercial vehicles as The General and Commercial Motor Insurance Company Ltd (G & C).

In 1967, V & G acquired the whole of the issued share capital of Metropolitan General Insurance Company Ltd (M & G). Veral Insurance Holding Company (Veral) was incorporated in Canada, in 1967, as a wholly owned subsidiary of V & G. In March and June 1968, the World Auxiliary Insurnace Corporation Ltd (World Auxiliary) and the Pioneer Life Assurance Company Ltd (Pioneer) were acquired by V & G.

In addition to the acquisitions named so far, V & G acquired substantial although not controlling shareholdings in Liverpool and County Discount Company, Vehicle and General Insurance Company (Australia) Ltd, World-Wide Assurance Co. Ltd, with percentage of issued equity capital acquired of 49%, 24% and 25% respectively.

The motor insurance was effective, popular and received a great deal of publicity in the press. In 1968 and 1969, V & G in common with most British companies operating in the motor insurance market, reported losses on motor underwriting accountd after allowing for wholly inadequate provisions for outstanding claims. Also, V & G had to face much increased competition at the time of severe inflation.

There was press speculation concerning the viability of V & G after the announcement of reduced interim dividends for the year 1970. In February 1971 at a meeting with the Under-Secretary at the Department of Trade and Industry in charge of the Insurance and Companies Department, it was disclosed that motor claims to the end of 1970 were £2 to £2½ million larger than expected. This meeting was followed by the decision to restrict the conduct of insurance business. On 25th and 26th February 1971 there was another meeting between the company and the British Insurance Association (BIA) to explore the possibility of a rescue operation by members of the BIA.

And finally, as the inspectors write:
"Over the weekend of 27th and 28th February, Cooper Brothers & Co., Chartered Accountants, on the instruction of the BIA member companies, reviewed the financial position of the V & G group." The result of the report was that no rescue operation would be mounted. On the afternoon of 1st March 1971 the directors announced that V & G was ceasing to trade and that petitions would be presented to the Court for the winding up of V & G and several of its subsidiaries. The significance of V & G to the British motorist is borne out by the fact that on the evening of 1st March 1971 the BBC flashed on the nation's television screens an announcement of the collapse of V & G.

1. Mis-management

The management and especially the executive directors of the company failed in the appreciation of their duties. The board was responsible in many areas of mismanagement.

a. Policy clashes

The disagreement as regards policy between managing director and financial director of the company was a sign of mismanagement and failure to keep peace between them, which was the responsibility of the chairman, caused personality clashes. These two who were responsible for divergence of policy tried to build up their own empire within the company and as the Chairman of V & G puts it down "a great deal of my activity was keeping the balance between these two gentlemen on certain policies and views."

b. Management information

Although the management and directors of V & G had sufficient information available to them, throughout 1969 and for most of 1970 the executive directors refused to accept financial results shown by management information on the grounds that the information available coming from inaccurate data processing in a . Also there was evidence that in 1969 and the early part of 1970 the management information was kept confidential.

c. Dominant Managing Director

The managing director of V & G was a man of forceful character and with a domineering personality who, with the aid of a generous salary policy, commanded the respect and loyalty of most of the senior staff of V & G. He liked to keep in touch with his staff at all levels, which caused him to bypass senior executives and caused considerable friction between directors and the senior executives in the last years of V & G. He also placed some restriction on the dissemination of important management information.

Disastrous Investments

The directors of V & G Australia who were also the directors of V & G UK were in a large measure responsible for the ill-advised venture into the Australian market. The investment was disposed of at a loss in excess of £500,000. V & G Australia committed a fundamental error in carrying out its stated policy of selective underwriting. There was misleading information about V & G Australia and apart from a comment published in the 1965 accounts of V & G, the shareholders were given no information at all about the progress of V & G Australia.

Data Processing Problems

Due to lack of experience of data processing staff and lack of help from IBM, the state of affairs in 1966 and 1967 was unsatisfactory and much of the information produced by the data processing department was unreliable. Information produced by a computer can only be relied upon provided the computer is being supplied with accurate data for processing, but in the case of V & G inadequate estimates of costs of motor claims were put on to the computer files during 1968 to 1970.

Lack of Appreciation of Unprofitable Motor Underwriting

While the offices of V & G had information available which made them aware that the provision for outstanding claims was inadequate, they allowed the 1969 account to be published with the inclusion of a wholly inadequate provision for claims. Also the audit work on the provision for outstanding claims at 31st December 1969 was insufficient. The results of operation shown by the 1969 accounts of V & G were misleading.

Lack of Control over the Agents' Accounts System

During 1967 the system was allowed to operate with totally inadequate control on amounts charged to brokers and not paid by them. Because of the lack of control on the system, V & G had inadequate information as to which brokers owed the various amounts comprising this balance, and therefore were unable to readily determine the collectibility of the amount outstanding.

Acquisition of World Auxiliary & Pioneer

This acquisition, according to the directors of V & G was a major factor in the collapse of V & G. This acquisition gave rise to continued losses in 1968 and 1969 which was mainly due to inadequate control over this acquisition. The damage to V & G flowing from World Auxiliary arose out of policies pursued by the V & G management. The substantial losses resulting were beginning to emerge at the end of 1970.

Another acquisition which was not supported by any proper reason was Pioneer which was a small soundly and conservatively run life company. V & G directors decided to acquire the control of this company without enough experience and too much commitments.

Lack of Board Participation

There was a clear sign of refusal to take full account of the views of the senior executives in 1969 and to work with them as a team for the benefit of the group. After publication of the 1968 accounts there was a revolution inside V & G general management in order to control and achieve things which they desired to do, but it did not take long.

Misleading Annual Reports and Accounts

The publication of annual reports and accounts of the V & G for the years 1966, 1967, 1968 and 1969 gave an increasingly misleading impression of the results of operations and of the state of affairs. The profits shown in the published account for the years 1966 and 1967 were overstated; in both years the auditors of V & G failed in their responsibility to make adequate enquiries. The interim report for the six months ended 30th June 1969 was wholly misleading and false in material particulars.

5.13.2 Conclusions

Vehicle and General Insurance Company Ltd was the case of an organisation which grew in size through many acquisitions, investment and formation of subsidiaries but its administration and particularly its accounting practices did not keep pace.

V & G was different from most of the other motor companies in many ways: with its aggressive sales policy it operated through brokers, to whom the high rates of commission were offered. It set out to attract careful private motorists by offering large no-claims bonuses. Expansion was rapid; V & G had a motor premium income (after deducting re-insurance) of £307,000 in 1961. This rose to one of £2 million in 1963, to £5 million in 1965, £12.8 million in 1967 and £17.1 million in 1969, which means a growth of 56-fold in eight years. This growth put strain on the company and its organisation, but V & G did not respond properly to the changes. Weaknesses in accounting and reporting were at the heart of V & G's difficulties.

5.14 John Willment Automobile

5.14.1 Background

John Willment Automobile (the public) was incorporated and began to trade in 1921. The public company was a 75% owned subsidiary of John Willment (Properties) Ltd, a private company of which Mr Willment was the majority shareholder.

In 1963, Mr Willment's private company "Car Sales" began to operate a new Ford main dealership at Twickenham. Shortly afterwards, Car Sales acquired the share capital of Kingston, a private company carrying on a similar dealership at Kingston-upon-Thames. In 1974 Car Sales acquired a controlling interest in the public company, then Wood and Lambert Ltd which carried on a Ford main dealership at Stamford Hill, and Mr Willment was appointed Chairman. As part of the same transaction, Kingston was transferred to and became a wholly owned subsidiary of the public company.

Up to this time, the public company had been efficiently and conservatively managed and it was in a sound financial position when the change of control took place, which was followed by a period of rapid expansion with borrowed money, which transformed the financial position.

The chronological events from the date of incorporation in 1921 are:

23 Feb. 1921	Incorporation of the public company as Wood & Lambert Ltd.
June 1921	Ford main dealership at Stamford Hill opened.
Dec. 1953	Commencement of dealings in the shares of the public company on the Stock Exchange following its flotation as a public company
March 1954	Incorporation of Car Sales
Nov. 1959	Incorporation of Properties
Jan. 1963	Acquisition of Kingston by Car Sales
April 1964	Acquisition of 1.9M shares in the public company by Car Sales

	Conditional contract entered into for the acquisition of Kingston by the public company.
	Appointment of Mr Willment as Chairman of the public co.
	Acquisition of Woodfords by the public co. from Mr T Wood, retiring chairman of the public company.
January 1965	Acquisition of Twickenham dealership from Car Sales
January 1965	Contract entered into for the acquisition of Kent & Surrey by Car Sales
March 1965	Issue of circular to shareholders in connection with the acquisition of Kingston
April 1965	EGM approving the acquisition of Kingston
November 1965	Name of the public company changed from Wood & Lambert to John Willment Automobiles Ltd
January 1966	Resignation of Mr Wood as director of the public co.
	Acquisition of Kent & Surrey by the public co.
March 1967	Issue of circular to shareholders in connection with the acquisition of Kent & Surrey.
November 1967	Issue of circular to shareholders in connection with the acquisition of various properties by the public co, from Car Sales and Mr Willment.
December 1968	Acquisition by the public co. from properties of an option to purchase a 25% interest in Automotive Eng.
May 1969	Resolution of the board of the public co. to acquire the remaining 75% interest in Automotive Engineering
November 1971	Resolution of the board of the public co. not to proceed investment in Automotive Engineering.
	Resolution of the board of the public co. to acquire from Marina development project at Cowes IOW.

9 October 1972	Suspension of Stock Exchange quotation
10 " "	Resolution of the board of the public co. to acquire a 90% interest in a sand and gravel excavation business at Havant, Hants.
31 May 1973	Appointment of Inspectors by the Dept of Trade & Industry
27 Sept. 1974	Issuing of circulars to shareholders giving them certain additional information about the private and public groups.
6 December 1974	Appointment of Receivers of the public co. and 8 of its subsidiaries.
24 December 1974	Appointment of a Receiver of Bedhampton

5.14.2 Causes and Symptoms

1. Acquisition Policy

One of the significant factors in failure of most expanding companies is the decisions taken for acquisition and investment which are mainly based on unclear objectives and policies of the company and the lack of proper appraisal by management. All acquisitions in 1965 by this company were carried out without proper regard to financing them. There was also examples of inexcusable delay in issuing circulars to shareholders in connection with the acquisition, e.g. Kingston, Kent & Surrey. The mistakes with regard to poor investment was evident in the acquisition of Brentford Properties.

2. Confused Transactions

There are a few transactions in this company which causes problems for the liquidity of the company, e.g. the transfer of properties from the private group to the public in 1967. The object was to find a remedy for the situation brought about by the outflow of liquid funds from the public to the private between 1964-1967. The transactions improved the appearance of the balance sheet, but did not help liquidity problems.

3. Lack of Proper Information System

The informal enquiries with no basic information was the basis of the commitment of public company to some projects e.g. East Cowes. The board was not able to assess the viability of projects due to the lack of proper information systems in the company. There was no data concerning the available financial resources or even the information regarding the company's expertise, personnel or experience for undertaking a new project. This caused wrong and sometimes rash decisions by the board, e.g. the Havant quarry project was undertaken on the basis of estimated costs by guesswork which was grossly inadequate and obsolete.

4. Ineffective Control

The inspectors quote "Having taken the decision to proceed with the project at East Cowes and Havant Quarry, the board of directors ceased to have any effective control over expenditure".

5. Interest Charges

By the end of 1973, £1,900,000 of borrowed money was invested by the public group in the projects with interest charges that caused financial problems.

6. Project Failure

The collapse of John Willment Automobiles Ltd was done, according to the conclusion of the inspectors of the Department of Trade and Industry, "as a direct consequence of two major attempts at East Cowes (Marina) and Havant Quay and the heavy interest charges which have resulted".

The basic causes of failure of these projects can be summarised as follows:

6.1 Major Diversification of Activities

The Ford strike in 1971 left Mr Willment disillusioned and pessimistic about the prospects facing the public group's business as Ford main dealers. He determined to diversify its activities into Marina developments which was a completely new activity to the company.

6.2 Lack of Elementary Information at the Board

It is inescapable that the board's decisions to proceed with the project on the information before them was one which no reasonable board of directors acting with ordinary competence could have made. The consequences of this was collapse.

6.3 Inadequate Planning and Forecasting

The original estimates of the costs of the projects were grossly inadequate. They were based on informal enquiries made by Mr Willment and had no independent validity. There was no accurate forecast or scheduling; no forecast of financial requirements.

6.4 Ineffective Control over Expenditure

Once the initial decisions had been taken to proceed with the above projects, the board of the public company ceased to have any effective control. This also caused escalating costs with more difficulties.

7. Inexperienced board members.

"One had been in the motor trade all his working life with no other experience, others were bystanders."

8. Too much ambitions and enthusiasm.

One of the reasons for taking the decisions to commit the public company to these projects was based on enthusiasm even though he knew it was not a viable project.

9. Overspending, delays and heavy interest charges, with unforeseen problems all contributed to the failure of the projects.

10. Irresponsibility of the board.

Another example is the failure and negligence of the board to advise the Stock Exchange and obtain approval of the shareholders in the case of the acquisition of the Twickenham dealership. The Marina site at East Cowes and the project at Havant.

11. Poor cash flow.

During the period 1964 to 1971 the business of the public group generated funds amounting to only some £317,000 and lacked self-generating cash flow.

12. Unjustified outflow of liquid funds from the public to the private which was another responsibility of the directors and board.

13. Poor trading results.

By comparison with other Ford main dealers, the public's growth, turnover and return on capital was low, which was mainly due to poor management and heavy interest charges.

14. Lack of reliable management information and budgetary control.

This was due to (a) failure to maintain up-to-date and reliable accounting records, and (b) lack of any full-time financial directors and accounting staff, (c) defective financial management structure, (d) irresponsibility of one of the directors, who was a Chartered Accountant; (e) irresponsibility of the board in maintaining adequate financial control.

In summary

This is a clear case of incompetence and mismanagement with some indication of dishonesty and irresponsibility.

15. Lack of appreciation of the duties of directors of a public company in the interests of the shareholders.

16. Inexperienced member as a M.D. of a project - the Marina.

17. Unbalanced and obedient board

18. Poor economic climate

19. Strike at Ford

One of the most significant symptoms of failure in this case was the lateness of accounts and reports. Its record of delay in publishing its accounts has been appalling: in 7 of the 10 years from 1964 to 1973.

20. Unclear policies and strategies.

This was the main basic cause of trouble, objectives of the company were iignored, policies were based on too fast expansion in too short a time and strategies based on uncertain, unclear and guesswork forecasts available resources and experience. The examples: all acquisition, investment and commitment to different projects. Poor expansion and investment money based on gearing over borrowing and under-capitalisation.

21. Irresponsible and incompetent board

This was clearly evident from different perspectives.

a. Delay in publication of the public company's accounts

b. Intercompany indebtedness

c. Inadequate, false, misleading and censored information supplied to its shareholders.

d. Board disputes over acquisition decisions.

e. Lack of appreciation of duties as a public company director

f. Lack of response to problems by the board on time

g. Over-optimistic chairman's reports.

h. Profit forecasts had been pure fiction and when there was loss it said 'satisfactory progress'.

k. Appointment of inexperienced members as M.D. of completely diversified activity.

5.15 Handley Page

5.15.1 Background

Handley Page, which was one of the first aircraft manufacturers to be formed in Great Britain, had prospered for 50 years from its foundation in 1909. Under the guidance of the founder, Sir Fredrick Handley Page, it built a series of military aircraft and civil airliners including the World War II Halifax and Victor jet bombers.

The Victor aircraft provided the company with the bulk of its business in the 1950s and early 1960s, but military orders started to tail off with the government's changed defence policy. The company was too small to carry the heavy costs of progressing on to jet transport development.

The next step was diversification into oil-filled radiators and brewery equipment which proved disastrous and eventually cost the company more than £1M.

Handley Page concentrated its activities on the small airliner and executive aircraft sector, as small airliners needed a relatively modest investment in development costs. A new project was Jetstream, an aircraft which was designed to carry 20 passengers at up to 300 MPH, with estimated total development costs of £3M and a price of £125,000 apiece. This project was accompanied by a re-organised leadership and was an immediate success. By mid-1966 the company had orders for 20 aircraft and in September 1966 the company announced orders for a further 100 aircraft worth a total of £12.5M. A few days later the government offered £1.25M just under half the aircraft's development cost.

The plans proved difficult to be achieved. The company started running into financial problems. The 1967 consolidated accounts showed that the company was heading for really massive trouble, turnover had slumped from £8.58M in 1966 to £5.97M as government work declined.

The last period:

In June 1969 the company failed to produce its full year figures on time and the share price dropped sharply from 18s to 6s9d. almost overnight. On the 17th day of this month a joint rescue operation was mounted with an injection of £1.25M in cash and replacement of five directors including the Chairman and managing director of the company. Optimism was again expressed by the new chairman and even the financial press quoted the chairman's comments that "our production problems are solved, the financial situation makes sense, now we have to sell." But the sales position deteriorated, the Americans cancelled their orders and wanted to take over the company. Barclays Bank appointed a receiver who asked the Americans either to buy the company or it would go into rapid liquidation. Craven who had invested a good deal of money and did not want to see the company go out of business agreed to buy the company's new subsidiary, Handley Page Aircraft, which had been formed by the receiver for Jetstream project for £14.2M. The London Stock Exchange suddenly cancelled the Handley Page listing. Craven took over formal control of Handley Page Aircraft at the beginning of December 1969 and the company was producing Jetstream five a month at the beginning of 1970. Finally Craven's health failed and the company in May 1970 petitioned the court to be wound up; the winding up order was made in June.

5.15.2 Causes and Symptoms

Too much dependence on a big customer:

Handley Page was another example of companies which put too much reliance on a single large customer and ignore the risks of losing the market and product once the customer changes his policy, as for example when the British government changed its defence policy and reduced military spending. The consequence was to diversify into the oil-filled radiators which proved to be a failure with a cost of £1M.

Investment Strategy:

When the company lost the military orders, it decided to diversify either into a new product or a new market. The first one, which was the oil-filled radiators, failed and the second one was to concentrate on the small airliner and executive aircraft for potential demand in America. The company rushed out for this project which was called Jetstream, and the place had been designed to carry 20 passengers at up to 300 MPH. The estimated total development costs and price were £3M and £125,000 respectively.

Lack of experience of the commercial world and the American market in particular, poor estimation, unreliability of product, late delivery, increasing costs followed by rash decisions to fit inadequate engines and the lack of an independent marketing and sales organisation all contributed to the failure of the project and diversification.

Financial Difficulties:

In 1966 the turnover fell from £9.71M to £8.59M. As Travers quotes: "The trading profit dropped from £532,999 to £457,555 after crediting £114,183 released from depreciation provisions by a property sale, and charging £171,087 in radiator losses and the cost of closing down the radiator operation. Handley Page transferred £225,000 from its 1966 profits to a special development reserve (compared with £400,000 the previous year), making the total reserve £1M. However £549,504 of Jetstream development costs were capitalised as an asset. If, following previous practice, these costs had been charged against profits of the year, Handley Page would have list £91,949."

Handley Page's 1967 consolidated accounts showed that the company was heading for serious trouble. The statement of affairs published by the official receiver showed that Handley Page made a profit of £264,000 in 1968 and lost £881,000 during the seven months of 1969 that preceded liquidation.

In June 1969 the company failed to produce its full year figures on time and share prices plummeted from 18s to 6s9d almost overnight. This was caused by liquidity problems as the deputy chairman, who joined the board later, commented.

Project Failure:

The Jetstream project which was based on the need of market and a survey that showed a potential demand in the American market was an aircraft capable of carrying up to 20 people at up to 300 MPH and a weight not more than 12,500 lb. The project attracted many orders and it was scheduled for the first flight in 1967. By the end of 1966 the aircraft project showed the signs of some difficulties. It was proved to be late, overweight, underpowered and far from the design performance specifications. The weight was 12% above original specification; following these weaknesses, the company lost some of the orders and financial difficulties started to appear. The company poured more money into the project by raising £1.1M from shareholders in mid-1967 and another £1.3M in October of the same year. By December the cost of each aircraft moved up to around £200,000, 60% more than original price estimates. The test flying programme suffered a major setback when the only prototype instrumented for performance flying was damaged in a landing test.

Poor management structure:

While the company was heading for disaster, the changes of members of the board, chairman and also creating a new management structure was in process. These were signs of underlying causes which were based on poor policies and lack of a proper control system. The company with that level of reputation was lacking its own sales organisation and marketing management.

Poor control:

Lack of control from production to finance was an important factor in the failure of the project and collapse of the company. Poor and in some cases too optimistic forecasts, poor scheduling and lack of production control to meet the original estimates and specification caused too much diversified results concerning delivery time, weight and power and became the important factors in Handley Page's only hope - Jetstream aircraft disaster. More important as the article by Travers describes "The company's accounts underline the need for constant and close scrutiny and for careful correlation between profit and loss and balance sheet figures". This need was not implemented by the company.

Board of directors:

There is evidence, as Travers quotes that "every word in the documents provided by the chairman was agreed by the whole board, the whole text was very carefully vetted indeed - you will find that our forecasts were subject to us being able to meet our specifications."

Another statement by the secretary of the company writes "Your board's confidence in the Jetstream aircraft continues and is shared by our distributors." This statement, which appeared in December 1968 showed too much optimism expressed by the whole board.

Misleading chairman's report:

In June 1967 while the Jetstream project was already six months behind schedule, overweight and underpowered and the company was financially in difficulty, the chairman presented an extremely optimistic report, commenting: "Once again I am able to report that your company is in a stronger financial position than it was last year ..... In summary, your company is on track and all systems are working satisfactorily."

This was a completely wrong picture of the situation and the company, as Travers points out, was now really beginning to feel the pinch of falling government orders.

5.15.3 Conclusion

The official receiver's comment on the collapse of Handley Page was "Misjudgement by the directors at the material times and incorrect assessment of the capital requirements of the Jetstream programme and dissipation of available resources in a mistaken policy of diversification and unrealistic anticipation of demands and profit availability of government conversion work which did not materialise." The official receiver puts more blame on the managing director and chairman of the company for shortcomings. The interesting comment by the company's chairman is that he blamed the Handley Page collapse on "inability to produce Jetstreams on schedule and to specification and to lack of capital to tide it over the period needed to reach earning point." Two more comments on the failure of the company by its directors summarise the causes of the failure as:

1. General weakness in technical and financial control
2. Jetstream acceptance difficulties.

Finally, Travers in his article, "Flight to Disaster" concludes that: The company collapsed and died because it tried to translate dreams into hard facts". Realistic planning and proper financial controls could have produced a commercially viable aircraft and kept costs within bounds. Travers also believes that the story of Handley Page has some lessons for accountants and recommends the accountant to keep an open eye for changes in accounting bases. He claims that the company charged aircraft development costs against profits up to 1966 and then started capitalising them. The only indication of the change in policy was a brief note in the chairman's report for 1966.

5.16 Blanes Ltd

5.16.1 Background

Amalgamation of John Harold & Blanes with Lever (Clothiers) Ltd led to incorporation of Bernard Holdings (Blanes) Ltd in 1954. Continued success led in May 1959 to the incorporation of Blanes Ltd as a private company.

Blanes, as a private company, so prospered that by June 1963 it could properly be described in the Financial Times as "one of the leading UK produces of fashion day and evening dress in the medium-price range". The company has an expanding export trade in Europe and Africa. The directors of the company seemed an ideal combination of production, salesmanship and finance plus a successful designer and another young salesman. In 1969 Blanes Ltd and its subsidiaries were widely regarded as a vigorous group of companies. It specialised in the manufacture of women's clothing. The company's share price had quadrupled in the 5½ years since the company went public upon an offer for sales on 1963, and pre-tax profits had grown almost as fast.

Lack of experience and appreciation of duties and responsibilities by the board caused problems. Mr H Bernard, chairman and mainstay of the business, retired in 1970, other directors resigned due to growing distrust, hostility and problems. The group virtually fell apart, and by October the company's share price was down to 3/- less than one-ninth of that in January 1969.

Final Stage (nearly 6 months):

26th May 1970	First intimation of Blane's bad trading Resignation of H Bernard and B Lever
5th June 1970	F Russle took the chair, according to the chairman's statement.
5th June 1970	Meeting of the board, and appointment of F Russle as chairman. Blanes were running at a probable loss of

	between £3000 to £4000 per week. Decision to reduce staff and expenditure (re-organisation).
11 June 1970	Notice of termination of service of Miss Ruchland with five weeks. She was a director of six years' standing and a designer for Blanes Dress House for some 16 years.
July 1970	Collapse of Bernard Russle Ltd, one of its subsidiaries
8 October 1970	Mr F Russell resigned as chairman of the company, also as chairman of Bernard Russel
16 October 1970	Announcement to the Press of the board's intention to appoint an independent chairman outside the fashion trade
22 October 1970	A circular was forwarded to shareholders.
23 October 1970	Press comments: e.g. Investment Chronicle, after the share price had dropped during the year from a peak of 19/- to 3/- and whilst questioning certain share sales by the family directors, pointed out that first warning to shareholders had come as late as the end of July 1970. There had previously been the bullish trend in the chairman's statement in Nov. 1969, and finally the article referred to the groups' misconceived optimism.
26 October 1970	Press comments and concern led to the suspension of the quotation in Blanes shares on the Stock Exchange. Loss of confidence in financial circles and uncertainty as to the future viability of subsidiaries, increasing liquidity problems.
30 October 1970	The formation of a committee to represent the institutional shareholders for possibilities of rescue.
11 November 1970	Extraordinary general meeting called for the purpose of putting the company into liquidation.

5.16.2 Causes and Symptoms

1. Lack of response to change:

As the inspectors quote: "Despite the fundamental change of status, after the public flotation of Blanes shares, their business attitude continued very much as before".

2. Lack of formal conduct of affairs:

The author believes, although this can be considered as a contributory factor of failure, but it is a sign of irregularity in an organisation.

3. Lack of appreciation of responsibilities and duties:

This was evident among the board members as the reports refers to it on many occasions. If one accepts this factor as a human element which exists more or less in different companies, then the question is 'how effective is the system and organisation they are working in? " , which means the underlying cause should be in the system and board selection. A symptom was lack of discipline for normal board practices.

4. Lack of competence and experience:

The directors were well suited to their roles as working directors of a relatively small private company, which was not at all the same thing as running a listed group of companies. "They relied heavily on their professional advisers, for they had no experience and little conception of the duties and obligations of directors of a public company." as the official inspectors write.

5. Pricing policy:

There was an unsophisticated method of pricing for garments in relation to its costing system and it was mainly arbitrary.

6. Poor financial management practices:

This evidence of unsatisfactory financial management practices was a lack of co-ordination in the methods of costing, pricing and accounting between the manufacturing and selling departments of Blanes Dress House. Financial control was also poor.

7. Inadequate succession policy:

The author believes this can be considered as a symptom of poor value system in this company, which is of great importance to the survival of any organisation.

8. Poor central administrative structure:

As the company becomes weak, the central administration loses its control and effectiveness. The signs of this weakness in this company were:

a. Insufficient co-ordination betwern various departments and various companies.

b. Lack of unity of audit responsibility.

9. Optimistic and false chairman statements:

A clear indicator of an ailing company is the phrases and words used by the chairman in his reports and statements to shareholders of the company. This was also a present symptom in this group which was given by misleading profit forecasts and the assurance that the group is doing well.

10. Lack of appropriate marketing organisation:

Once the company fails to recognise the changes needed then it fails to provide the requirements of running the company. The group lacked an appropriate marketing organisation because it was thinking of running the company as before.

11. Management information system:

One can expect to see a weak information system and communication in a failing or failed company. The group's central information system was poor and ineffective. The information was wrong and manipulated, especially the accounting data.

12. Poor financial results:

The symptoms of failure can be seen by experts in the financial results of a company. This group's financial results were deteriorating after the previous difficulties due to managerial causes and other factors such as the collapse of the group's subsidiaries. This followed by a declining of share prices, press comments on loss of confidence and collapse.

13. The manner of sales of shares by directors:

There is evidence of selling of shares by some directors without the knowledge of other directors, which caused

a. distrust and hostility in the board room

b. Abuse and violence

14. Irresponsibility of auditors:

They failed to put more pressure on the board to take corrective steps to remedy the shortcomings in accounting procedures.

5.16.3 Conclusion

Blanes Ltd failed because the family directors were unwilling to change methods which had been adopted for a small private company, but not for a listed public company. The group failed because it was unprepared to become public and lacked the requirements of being a member of the public sector. More important was, as inspectors quote "lack of realisation and appreciation of responsibilities and duties of the board and directors as members of a public group which is supposed to be more organised, better equipped and have the ability to adapt and respond to change."

5.17 Bernard Russell Ltd

5.17.1 Background

Bernard Russell Ltd was incorporated as a private company on 24th November 1964, it was the creation of Mr Harry Bernard who was the chairman of Blanes Ltd.

In 1964 Blanes was to expand into jersey fabrics as part of its policy of widening its interests in ladies' wear. The company was formed with a share capital of £1000 and Mr R. a sales manager in a sportswear concern having no previous experience of management outside sales, as Managing Director. There was an agreement that working capital of the new company should be provided by Blanes. As an incentive Mr R was given 250 shares and was not required to make any payment therefor. The remaining 750 shares were all owned by Blanes. The company was financed by substantial loans from its parent company and its sales were running at the rate of nearly £1M a year, gross profit for the year ended 30th June 1969 was £262,409 and net profit of £60,312. On 19th November 1970, as a result of an investigation by an independent firm of Chartered Accountants, two liquidators were appointed.

The initial success of the company was considerable in terms of trading results, so that within five years of its formation the company's sales had attained the annual rate of nearly £1M, but there were significant defects underlying the company's operations.

Bernard Russell Ltd was incorporated as a separate legal entity but was never under the management of an effective board. Therein lay the seeds of failure. It operated much as if it were a department within a parent company, yet at the same time was only subject to a minimum of supervision by the parent company directors. The public shareholders in Blanes suffered a total loss on a substantial investment of group funds in this ill-conducted venture. Finally, the company ceased its trade in November 1970 and appointed a liquidator.

5.17.2 Causes and Symptoms

1. Lack of formal directors' meeting to review the operation of the company.

2. Poor organisation:

Undefined authority and unclear responsibility and even job specification was evident in this company.

3. Incompetent managing director:

Managing director of the company was always under the domination of the parent company directors and lacked both the power and competence of a managing director. As the inspectors quote "Managing director was a salesman with no managerial experience."

4. Inadequate accounting system:

The accounting practice of the company was in a confused state which was mainly due to joint auditors without division of duties, co-ordination and exchange of information.

5. Lack of appreciation of duties:

This was an evident sign of weakness in this company among the members of the management team and also joint auditors. The main reason was unclear lines of responsibility and inadequate organisation system and management co-ordination.

6. Accounting manipulation:

The fear of the man on the top causes manipulation of accounts by inflating stocks and profits.

7. Poor succession policy:

The company did not have any planned policy for selection of successors, to the family directors when they resigned because of their ill-health.

8. Resignations:

This is a symptom of some troubles. The high turnover of labour and especially directors indicates the weaknesses. Resignation of designer and director and the dispute among board members were warning signs in this company.

9. Relationship with parent company:

There was a confused relationship between the parent company, its directors and the company which was a contributory factor in poor administration and lack of leadership in the company. More important was the company's lack of identity.

10. Idle board due to the poor value system:

The inspectors, in a part of their report,refer to the board and stress: "Employees were appointed to the board to give them the status of directors but without any intention that they should take part in policy decisions or even be advised of the state of affairs of the company". The board never met to review the operations, accounts of even the budget.

11. Irresponsibility of accountants:

Although the main problem in this case was the existence of an uncooperative joint auditors, but their irresponsibilities are clear from this expression: "They never attempted to ensure that adequate audit procedures had been applied and did not take adequate steps to satisfy themselves as to the valuation of stock." This gave a misleading picture of the company and having concealed the management deficiencies, remedial actions were never taken.

12. Lack of a proper information and control system:

There was no sign of any effective exchange of information. Unwillingness together with lack of co-operation and co-ordination of different departments were the reasons that company was not able to have an effective information system. The main cause was at the top and the board.

13. Too much influence of family directors, mistakes in costing, poor production control, lack of liaison between members of the management team, poor conduct of business and unwillingness to take advice from senior executives, by the managing director are other contributing factors in the collapse of this company.

5.17.3 Conclusions

The conclusion of the failure can be summarised as a gradual process of mismanagement with lack of identity and authority which was due to influence of the parent company directors. Also, failure to establish an independent but adequate management structure with clear policies and responsibilities.

5.18 Court Line Ltd (Founded 1905, Failed August 1974)

5.18.1 Background

Court Line was founded in 1905 as an operator of tramp steamers. The ownership of the business was restructured in 1929 and again in 1947. The present Court Line company was incorporated on 12th December 1928 as Cary and Strick (Steamers) Ltd. It was converted to a public company on 12th June 1947 and its name changed to Court Line Ltd on 22 October 1952.

Court Line consisted of over 100 companies, including dormant and non-trading companies and those of limited activity. It was organised into 4 divisions, consisting of 52 constituent companies. The divisions were:

1. Shipping and group management
2. Shipbuilding, shiprepairing and engineering
3. Aviation
4. Leisure

The main business throughout the period from 1905 to the early 1960s was tramp steamers.

In 1961 Mr John Young joined the board and in 1963 he became managing director, succeeding the then managing director, the Hon. W S Philipps, who became chairman and remained until the date of liquidation in August 1974. 1963 saw the start of considerable changes in the company. Between 1963 and 1966, Court Line disposed of its tramp steamers and invested progressively in tankers. In 1965, Court Line acquired Appledore Shipbuilders Ltd which was a small company, pioneered the first covered-in shipyard in the UK with government loans. In 1965, Court Line acquired Autair International Airways Ltd. In 1968-69 Court Line showed interest in the Caribbean and in June 1969 sites were acquired on St Lucia, where two hotels were built, the Halcyon Beach Club (opened in Nov. 1970) and Halcyon Days (opened in June 1970). In November 1969, the aviation side changed its image, aims and finally its name in January 1970 to Court Line Aviation Ltd. It became closely connected with Clarksons Holidays Ltd, which catered for mass travel at the cheap end of the market and became their largest customer. Clarksons Holidays had a number of competitors and a price-cutting war raged for some years, indeed up to the time of the joint collapse of Court Line and Clarksons Holidays. This war at times reached such heights that package holidays were being offered at below cost.

In January 1970 Court Line extended its shipbuilding side by acquiring North East Coast Shiprepairers Ltd and amalgamation of three companies namely,

1. Middle Docks and Engineering Co Ltd
2. Brigham and Cowan Ltd
3. Mercantile Dry Dock Co Ltd.

In August 1971 Court Line acquired the Leeward Island Air Transport Services Ltd, the local Caribbean airlines. In February 1972, the group bought a hotel on Antigua which was extended and re-opened as the Halcyon Cove.two years later and at the same time bought from a liquidator another hotel, renamed the Halcyon Balmoral in Nassau. In June 1972, the group's shipcuilding expansion was completed by the acquisition of Doxford and Sunderland Ltd and its subsidiaries (D & S) which included shipbuilding and shiprepairing yards and other engineering works.

In August 1972 Aviation ordered and entered into leasing agreements for two Tristar aircraft and took options on three others. In April 1973 Court Line acquired 85% of Clarksons Holidays which by this time had grown beyond its own capabilities and its parent company's expectations with resulting heavy losses. Clarksons Holidays finances were unsound, its recording and booking systems were faulty and SHI were not disposed to inject further large sums of money into it.

In June 1973 the group acquired Owners' Services Ltd (OSL) a holiday villa business. In May 1973 Court Line acquired The Associated Travel Leisure and Services Group (ATLAS) which specialised in student travel and which operated an advance booking charter business. In October 1973 Court Line bought the R Harris & Son (Builders) Ltd group of companies (Harris), a Devon based building contractor and developer.

In February 1974 the group took over, not the companies, but the passenger bookings of the Horizon group, an inclusive tour operator specialising in the upper end of the market. At the same time, it acquired a 58% interest in a related, but independently run, company called Horizon Midlands Ltd. In March 1974 the group bought a controlling interest in its third hotel in St Lucia, the Marigot des Roseau. In March 1974 also, the group accounts up to 30th September 1973 were published prior to its annual general meeting in April. The treatment of goodwill in these accounts resulted in the group exceeding its borrowing powers.

In June 1974 Court Line approached the government for assistance and as a result an agreement was made for the government to acquire all its shipbuilding, shiprepairing and engineering interests. On 15th August 1974 the principal companies in the group ceased trading. Up to the evening of this day, it had been running its various businesses in the ordinary way - receiving and paying out money, giving credit and accepting credit. In particular it had operated up to the last moment its holiday flights.

Financial Position of the Group as Shown in the Published Report and Accounts at 30th September 1973

Net tangible assets of the group at 30th September 1973 were £13.108M.

The debt-to-equity ratio was 5.6 to 1 - much higher than average in UK.

The borrowings amounted to 3.15 times the net tangible assets.

Trading profits of £8.114M (according to directors' report) are reduced to

£4.853M by including Clarksons losses and this further reduced to £996,000 after deducting interest costs.

The aviation and leisure division made a loss of £3.532M.

With this financial position, the group had to face the consequent problems and threats of oil crises, the 3-day week, the slump in the shipping market and the reduction in the leisure market, Arab/Israeli war increased oil prices, restrictive prices and incomes policy and changing general economic climate in this country and overseas.

<u>The Final Stage of Failure</u>

This stage which covers the events that occurred between the 30th September 1973 and 4th April 1974 is of great importance both in analysis point of view and its considerable impact which was mainly brought about by unjustifiable and rash decisions and policies. On 30th September 1973 the financial position of the group was in a state of bleeding. In November 1973 Court Line purchased R Harris and Son (Builders) Ltd and its subsidiaries. In the same month, the arrangement of the Pallian Yard loan with the Department of Trade and Industry was completed. This was a £9M loan to convert the Pallian yard into a covered yard as Appledore-type. The total cost was estimated at about £24M; one of the pre-conditions of the loan was that Court Line should first put up £3M towards a reconstruction scheme which was never put up by unable Court Line. At the end of 1973 and early 1974 the ailing company came face to face with external factors: Arab/Israeli war in October, difficulties with oil supplies, increased oil prices, 3-day week working in UK, reduction in demand for leisure market. The first effect was on the group's shipping interests and next was the Aviation and Leisure Division which suffered in a declining market.

The impact was soon seen in the cash position of the group and increased problems for Clarksons difficulties. Despite this critical situation, Court Line acquired on 1st February 1974, the business and goodwill of Horizon Holidays Ltd with a chaotic accounting record. This was a big mistake and a most unfortunate acquisition for the group. This happened in the absence of risk awareness and uncertainties surrounded the economy of the country and the whole world.

In February 1974 Court Line made another mistake with taking a 10% stake in a Consortium interested in North Sea Oil and gas called the Van Dyke North Sea group, by a loan from Barclays Bank. On 22nd February Court Line issued a preliminary profit announcement disclosing a profit (before tax and extraordinary items) of £5.02M before deducting loan stock interest of £320,000 and excluding Clarksons losses of £3.18M. On 13th March 1974, the published accounts of the group were available, but they received adverse press comments and Court Line's ordinary shares immediately fell from 38½p to 30p as against the 1973 peak of 170p.

The breach of its borrowing powers was a disturbing feature that the group could not and did not realisé until the end of March. The group was permitted under the articles to borrow up to five times its capital and reserves less goodwill, while the published accounts showed capital and reserves less goodwill amounting to £6.3M and borrowing of £41.2M, which was much greater than their permission.

During 12th March 1974 and 4th April 1974 Court Line came face to face with disturbing facts such as

a. the lack of accurate up-to-date information

b. High gearing position of the group

c. Breach of its borrowing power

d. Press comments

e. BTI advice of disposal of all the shipping fleet

f. Assets disposal advice.

g. Unhappy and disturbed advisers and interested parties.

But there was another mistake giving an over-optimistic picture of the group's position and future prospects in the chairman's report, and finally Court Line was, on 15th August 1974, forced to go out of business and made headlines as 'Big Catastrophe'.

One of the desires, which proved to be a disaster, of Court Line was "to show pre-taxed profit at their largest even by the adoption of unconservative, inconsistent or illogical accounting practices". The 1973 accounts received significant adverse comments from the financial press regarding that desire or weakness.

5.18.2 Causes and Symptoms

1. One-Man Idea

Although the group was controlled by the directors, working as a team, major decisions were principally influenced by the personality of Mr Young who was the Managing Director and an influential and dominant figure in the group, especially on matters of policy. His approach to the business was too optimistic, with too much influence on his fellow directors.

2. Inner Management Team

This was a team consisting of Mr Young and a few directors close to him for important executive decisions in an informal manner which was against their duties.

3. Lack of Formal Management Information and Reporting System

This was a clear feature of the group which was a contributory factor in poor communication and inadequacies of investment and acquisition decisions.

4. Ineffective Management Accounting Arrangements

This signs of this factor could be seen from

a. lack of discipline in procedures

b. Poor methods of submitting returns

c. Inadequate explanation of trends and variations

d. Inaccurate returns and forms

5. Board of Directors

Irresponsibilities of the board's members was a significant factor in most of the inefficiencies and inadequacies of the group. The group was controlled by a very small head office organisation under Mr Young. The sign of this irresponsibility was clear from its board meetings, which were a formality for legal documentation of decisions which had been taken informally. This board was lacking a balance of knowledge and power due to influence of Mr Young.

6. Lack of adequate and proper central administration structure and control

The sign of this inadequacy was the increasing divisional difficulties, poor bookkeeping and accounting methods and finally losses due to poor performances.

7. Breach of duties

a. unofficial loans and tips to Mr Macqueen who was Aviation Director of Clarksons Holidays before Court Line's take-over and was never employed by Court Line.

b. this loan was never officially or formally mentioned at board level.

c. the existence of the loan was deliberately and effectively concealed in the books of accounts and was not disclosed in the published accounts.

d. serious loss due to this loan transaction.

8. Unwillingness to accept advice

Although this caused some dispute between the group and its financial advisers and merchant bankers, due to refusing to take legal advice before entering into the agreement of May 1972, regarding buying £500,000 ordinary stock of Doxford and Sunderland Ltd (D & S), but in itself there was a symptom of ineffective board and one-man rule.

9. Acquisition Policy

This is the starting point of most crises for most companies which are in the process of development and diversification. Court Line suffered more in its acquisitions which was due to inability of the company in proper feasibility studies, adequate research of factors involving or surrounding the acquisition, and too optimistic forecasts based on poor assessments of information available. There are few examples to prove these weaknesses which became the characteristics of acquired companies, for instance

9.1 the group's involvement with the Lock arose from an over-optimistic assessment of 1973 tanker boom market. This alone brought a loss of £1M.

9.2 too ambitious acquisition: This sort of acquisition usually stems from previous success as happened to Court Line whose previous acquisitions of Appledore proved to be a success and it made the group to acquire D & S which resulted in a great loss and its financial consequences contributed to the collapse of the group.

Causes of D & S Failure

1. Lack of assessment of management abilities and its weaknesses.
2. Lack of adequate research for acquisition
3. Underestimation of modernisation costs and overestimation or profits
4. Problems due to overmanning
5. Over-priced bid
6. Labour relations and strikes
7. Too much enthusiasm of previous success.

9.3 Expansion and acquisitions: Another example of expansion that Court Line experienced was a chain of expansion-acquisition-expansion which had great significance in the group's collapse. The Airline activities expansion in the late 1960s with Tristar resulted in acquisition of the failing Clarksons Holidays and Horizon and finally the expansion of activities into the leisure business. The whole aviation division can be a completely separate case in analysis of company failure and therefore it is analysedd in some detail.

10. Cash flow problems

The financial difficultues and changing trends of different items and ratios are more symptoms than causes and appear as a consequence of previous mistakes and troubles, as it happened after different illogical acquisitions and investment cases e.g. Van Dyke.

11. Accounts manipulation (artificial accounting)

Another warning sign and symptom of ill health of the company and its declining position either financially or non-financially. This is done to 'window-dress' the accounts and mostly the balance sheet in situations where the company needs more credit and needs to attract the attention of creditors and satisfy its shareholders.

12. Investment policies

Court Line's investment policy was in a field which, from the start, proved to be a failure. The characteristics of £679,000 investment in Van Dyke North Sea group were

a. it was in a very crucial time of the group's history
b. it was commercially not sensible
c. it was too speculative
d. Lack of capabilities and experience
e. Investment with borrowed money in a situation when the group was already in a highly borrowed position
f. Lack of any satisfactory reason for investment.

5.18.3 Aviation and Leisure Divisions

5.18.3.1 Background

The Aviation Division arose from a decision made during 1963-64 to change from tramp cargo vessels to diversify and expand. In 1965, Court Line purchased Autair International Airways Ltd for £215,000 cash. This company had built up a network of UK scheduled and international charter services. The company's name was changed to Court Line Aviation Ltd and maintained its operation as an airline on the charter principle.

Court Line became increasingly identified with Clarksons Holidays. The prospects of tour industry and encouragement of Clarksons Holidays entered Court Line into options to obtain Lockheed Tristar aircraft. In January 1972 Lockheed submitted proposals for the Tristar, which was then under development stage. The evaluation group of Court Line recommended to the board that two Tristars be ordered for delivery in Spring 1972 and to purchase further three later. The two aircraft were built subject to considerable modifications to suit the Aviation and to carry 400 passengers. The price quoted per aircraft was US $15,410,274. On 1st February 1971 a report was submitted to the board detailing the position of the Tristar project including significant increases in both capital and operating costs.

On 4th February 1971, Rolls Royce was placed into the hands of the receiver and the development of the RB211 engine which was to be used in the Tristar aircraft, became increasingly uncertain. On 28th February 1973 after nearly two years the Tristar with the same engine continued and the first aircraft was delivered with the sale price of US $19,857,050. By 26th July 1974 the Tristar was considered as "inflexible, unsuitable and unreliable". The total costs involved in the Tristar projects, excluding the interest costs was approximately £23M.

To secure their position Court Line Aviation obtained a five-year contract from Clarksons Holidays without any underlying guarantee from it parent company shipping industrial holdings Ltd (SIH). In April 1973 Clarksons Holidays was in danger of collapse as a result of substantial losses, and Court Line were put under pressure to take it over.

Court Line found themselves in a difficult position if they refused to take over Clarksons, SIH indicated that Clarksons might be put into liquidation, Court Line would then have been left without much experience and great problems. They also knew that Clarksons organisation and management recirds were in a chaotic condition. Nevertheless they acquired 85% of Clarksons and the injection of £6.2M by SIH as working capital to finance Clarksons losses.

In 1973 Clarksons was unable to retain its share of the falling market and when Horizon, which was trading in the 'up market' was in danger of folding up Court Line acquired the passengers but not the company and at the same time acquired 58% interest in a related company - Horizon Midlands Ltd.

In 1971, as part of a developing interest in the Caribbean, Court Line acquired the local airline LIAT which was to face some problems and difficult political situation. Also, for extending the package holiday business from the UK and North America to the Caribbean and to market the hotels, Court Line set up a company in Toronto and acquired 51% of a New York Agency company. The whole Caribbean project was under the control of John Young, with no formal management structure.

5.18.3.2 Causes of Failure

For the identification of the causes of the Aviation and Leisure Group failure one has to take into account the factors related both to this division of the group and the whole group. Having considered this importance the major contributory factors were:

1. Lack of clear strategy (inability to realise that their business was a charterer and not an operator).

2. Purchase of Tristar aircraft.

3. Poor appraisal of other alternatives or available aircraft and failure to give any chance to other proposals e.g. Douglas.

4. Failure to anticipate the problems of sole operator of a new 400-seat aircraft on this side of the Atlantic.

5. Collapse of Rolls Royce and the RB211 project.

6. Lockheed's financial problems

7. Escalating costs and prices

8. Technical problems in introductory stage

9. Unreliability and inflexibility of Tristar which caused considerable losses.

10. Multiplicity roles to use the aircraft (this was a symptom of inflexibility of the business).

11. Poor market assessment and feasibility studies

12. Lack of demand due to falling market

13. External factors such as the oil crisis in early 1974, 3-day week, economic climate of UK and overseas.

14. Lack of appreciation of Clarksons Holidays ever-present problems in its highly competitive, highly sensitive industry.

15. Administration problems of Clarksons

16. Chaotic records and accounts

17. Lack of up-to-date information

18. Investment in the Caribbean hotels

19. Lack of control of capital and expenditure

20. Poor marketing

21. Accounting manipulation and trading losses

22. Lack of management structure

23. Mr Young's personal control and involvement

24. False Chairman reports.

5.18.3.3 Clarksons Holidays

The major problems of Clarksons Holidays were:

1. Weak basic administration and management structure

2. Over-optimistic budgeting

3. Lack of adequate concentration on profitability and turnover

4. Lack of control over overheads

5. Ineffective top and middle management due to failure of administrative systems

6. Problems in achieving its budgeted programmes due to inflation and floating of the pound.

7. Lack of management accounting system

5.18.3.4 Conclusion

Although there was no single reason for the collapse of Court Line, but generally most of the problems started from the top where there was not a proper responsible body to decide on crucial situations such as investment, expansion, acquisition and diversification. Once this was done, there was not adequate arrangements, flows and control, and with all these setbacks the last mistake was the false and too optimistic forecasts, reports and statements based on manipulated and window-dressed accounts and balance sheets.

Court Line, as the inspectors quote, "is a case of humble beginnings, rapid diversification over a wide field, ambitious acquisitions, very heavy borrowings, over-optimism, an expansion and disastrous incursion into the

Caribbean, inadequate overall management and a share of ill-luck and, finally, a leading personality - the managing director."

5.19 Causes and Symptoms of Large Companies Failure

The relationship between cause and effect in business failure is of considerable importance and too often is forgotten or neglected. Each successive effect becomes the next cause in a series of causes and effects. It is illusory to search for an ultimate cause for the collapse of a company. Since many factors combine to guarantee the survival and success of companies, a variety of forces will have to combine to cause failure or to correct the problems (turnaround and rescue operation). Analysis of failed companies evidences the inability of management to perceive danger signs before they become issues of great public concern.

The range of causes and symptoms of failure for each individual company appear in the body of cases, therefore it would be useful if the most common causes of failure emerging from the analysis of large failed companies are identified.

The list of causes and symptoms of failure may, with hindsight, seem obvious and elementary; however it is in the nature of human behaviour to admit unpalatable though often obvious truths. In the cases studied this is clearly demonstrated by the chairman's statements and other reports which present a picture of their companies which no objective analysis would possibly substantiate. These are just demonstrations of the difficulty in recognising unpalatable truth. The need to distinguish between causes and symptoms is obvious; if one wishes to reduce the chances of failure one might do so by adopting a warning system and removing the underlying causes. Otherwise there is a danger of treating symptoms and effects rather than the basic causes. If the root cause of the difficulty which often contains an unpleasant truth is not correctly diagnosed the application of short term remedies will do no more than postpone or temporarily alleviate the trouble which will appear when control is relaxed.

5.19.1 Causes of Failure

The author believes that a significant cause of failure is the ignorance and lack of understanding of management with regard to the fact that many of their problems are rooted in 'time'. In particular, not enough attention is given to considering how problems will develop in the future. Furthermore correct and control actions are often taken too late which result in aggravating the problems and accelerating the failure.

Often failure of a company is attributed to the shortcomings of a single individual; i.e. the chairman, managing director or chief executive. This is too simplistic an explanation; at certain times in the development of a company one strong man who can control the company is beneficial whilst at other times collective participation would be desirable. Therefore time is an important factor which must be taken into consideration in analysis of company survival and failure.

In failed companies management often fails to understand the basic principles under which they operate and to ask fundamental questions such as "what business they are in or should and will be in", and to ensure that the questions are carefully studied and correctly answered. The example of this type of weakness, which is often relevant to the strategy of the company, can be seen when the companies studied found themselves in positions where they were expanding or extending their activities, e.g. Handley Page "Diversification into the oil-filled radiator and brewery equipment", Roadship Ltd "reckless and ill-thought programmes of expansion", The Vehicle and General "Acquisition of Pioneer without enough experience and too much commitment", John Willment Automobile Ltd "All acquisitions in 1965 without proper regard to its objectives, ability and financing them", Court Line "the acquisition of Clarkson Holidays, group's investment in the Lock, etc ", Aviation and Leisure Division of Court Line "Acquisition of

Horizon and Horizon Midland Ltd without considering that their business was a charter and not an operator".

The failed companies gave evidences of ignorance and inability in very classic questions. They often diversifidd into products, markets, processes and services without asking a simple question; why, and finding an important answer: how to expand ?

The list of causes of company failure presented below is directly derived from examination of histories of companies in this chapter based on published reports of official inspectors appointed by the Department of Trade to investigate the affairs of these companies, also in some cases interview with actual liquidators and Official Receivers, and reports of experts. The items constituting this list are given in an order, by the author, which can provide a pattern of failure or represent the process of company failure as follows:

1. Unnoticed residual risks and difficulties during a growth phase
2. Inadequate appraisal of change
    - 2.1 Recognition and identification of needs and requirements
    - 2.2 Planning for change
    - 2.3 Implementation of change
        - 2.3.1 Resistance to change
        - 2.3.2 Low and inadequate response (partial response)
        - 2.3.3 Wrong response
        - 2.3.4 Ignorance
    - 2.4 Control of change
        - 2.4.1 Monitoring
        - 2.4.2 Review
        - 2.4.3 Feedback

3. Development of weak organisational structure and systems

   3.1 Information, communication and control system

   3.2 Value system

   3.3 Weak top management team (board of directors and chief executive)

      3.3.1 One-man idea (domination and rule)

      3.3.2 Unbalanced skills

      3.3.3 Non-participant team

      3.3.4 Management gap

      3.3.5 Lack of proper risk awareness and assessment

      3.3.6 Unjustified investment and expansion decisions

      3.3.7 Big and too ambitious projects

4. Financial crisis

5. Creative accounting

6. Accumulated internal problems and unidentified risk areas

7. Unpredicted external factors

   7.1 Economical

   7.2 Technological

   7.3 Political

   7.4 Social

   7.5 Others

8. False statements, reports and accounts

9. Too optimistic profit forecasts

10. Rights issues to provide more money for dying projects

11. Rash decisions for too-late rescue operations

12. Sharp declining of share price

13. Collapse of confidence in financial circles and business community

14. Late publication of accounts

15. Cancellation of orders by customers, rush of creditors and refusal of

suppliers to provide the oompany's requirement and lack of support by banks, finance houses or government.

It should be noted that the order of items in importance is not the same for each company. The significance of these factors vary from company to company according to type of industry, complexity of organisation, type of market and others.

All the failed companies in the present study showed these weaknesses causing a wide range of problems and sub-causes, resulting in the collapse of corporations with millions in resources, with images of national institutions, with the power to hire the very best management and technical talent in the world.

5.19.2 Symptoms of Failure

Peter Drucker defines symptomatic diagnosis as the method used by managers based on experience rather than upon analysis which is only permissible where the symptoms are dependable, so that it can be assumed that certain visible surface phenomena pertain to certain definite diseases. He suggests that "the manager must assume that symptoms do lie, knowing that every different business problems prdduce the same set of symptoms and that the same problem manifests itself in an infinite variety of ways, the manager must analyse the problem rather than diagnose it."(57).

However the symptoms of business failure can be generally divided into financial and non-financial ones. The emphasis of this chapter is on those non-financial signs which are visible more or less in failing companies. These signs can be seen by outsiders during a company visit, or tour of premises. It can be seen by customers, with occasional cutting of prices to improve flagging sales, suppliers may see the weakness sign when they see delayed payment, workers will feel the danger when the company cannot give them their wages on time, middle management can observe it when the stocks are rising, certain decisions have been postponed, products are outdated, cash is short, repairs have not been carried out, customers are complaining; bankers are able to see it through the accounts. The investment analysts, auditors and creditors might see different signs. Policy clashes at the board, one man rule, too much paper work, low morale, poor communication, late and wrong reports, creative accounting, high labour turnover, and resignations are among the signs that top management fail to see or occasionally conceal these symptoms from themselves, as K Cork states "their motive for doing this is very seldom evil and almost never fraudulent; it is done simply to keep going, until 'better times' come." However what appears at first sight to be the elements of problems rarely are the relevant or really important elements; they are at best symptoms. There is no doubt that "if there is an awareness of the risk, a large number of creep areas can be monitored and protected by routine reporting." The importance of non-financial symptoms is that they can be seen by experienced businessmen and experts either inside or outside the company and the signs that management often do not conceal them. Management of a company in trouble often manipulates the accounts and presents a window-dressed balance sheet to cover the financial signs of company weakness, but rarely can conceal the low morale of employees.

The author is of the opinion that the monitoring of financial and non-financial symptoms can provide an important guide to recognise the disease and the integration of symptomatic diagnoses and causal analysis can present a valuable tool for the health appraisal of companies.

Although it is possible to list the non-financial symptoms for failed and ailing companies, it is particularly useful to classify them in a form which can give a better explanation than a list. The classification made by the author is based on areas of activity in the company and the symptoms are those which have been exhibited by the companies studied. Exhibit gives a general picture of the non-financial symptoms of failed companies. It should be noted that some of these signs might be displayed by non-failed companies, although these companies would not be particularly highly successful ones. It should also be noted that some of these symptoms can be considered as secondary or sub-causes in the process of company failure.

AREA OF ACTIVITY	SYMPTOMS
FINANCE	Too voluminous financial reports to hide the facts Guesswork pricing and costs Chronic shortage of working capital Delays in payment to suppliers Delays in payment of wages Different accounting procedures in various divisions Indequate financial staff Inconsistent financial data Delay in yearly publication of accounts
RESEARCH AND DEVELOPMENT	Different design changes Poor innovation Out-dated product design Over-weighted prototype product
ORGANISATION	Low morale among staff Gaps and overlaps in responsibility Too much resistance to change Obscure lines of authority and responsibility
PERSONNEL	High labour turnover Frequent management resignations, dismissals or appointments Absenteeism Overmanning Inadequate successions Age mix and skill among different departments unrelated to business needs
ADMINISTRATION	Lack of co-ordination of activities Poor communication between departments and within them Too much paper work Lack of attention to different projects and products

AREA OF ACTIVITY	SYMPTOMS
PRODUCTION	Many technical problems Reworking of products Over-running in cost and time in the production stage Over-weighted products Products unrelated to market specifications Poor factory layout and production flow Too much dependence on a big project Out-dated manufacturing methods
MARKETING	Late delivery and shipment Losing market share Poor distribution of products Ineffective services Frequent customer complaints Loss of confirmed and unconfirmed orders
BOARD OF DIRECTORS AND TOP MANAGEMENT STRUCTURE	Domination of one man Policy clashes at the board level Informal board meetings Composition of the board Idle members - 'Yes Sir' type men Too many meetings Unwillingness to get advice Breach of duties Lack of attention to reports Hostility and disputes Too many acquisition in short period Rash and unjustified decisions based on enthusiasm of members

It can be observed from the table of non-financial symptoms that some of these signs have been given as causes of failure, which need a brief explanation.

As was already stated in the chapter, the relationship between cause and effect in business failure is very important when each successive effect becomes the next cause in a series of causes and effects, e.g. creative accounting is the symptom of an underlying cause which is in general called bad management. This is the effect or the sign of a primary cause which becomes a secondary cause when by its application management provides misleading reports, optimistic profit forecasts etc to raise more money from shareholders and creditors and pour into dying projects of a company which is bleeding to death. Another example is an unbalanced board, which, the author believes, is the effect of a poor value system applied in the selection of the board's members, but this becomes an important sub-cause or a significant secondary cause which develops many weaknesses and problems. Therefore an objective look at the symptoms can provide a substantial guide on how to identify the underlying causes.

Having considered the non-financial symptoms for various functional areas, now it is the management responsibility to interpret them adequately and properly, because the danger is that sometimes the most visible symptoms are the least revealing ones. Management may see, Peter Drucker quotes, "a clash of personalities, the real problem may well be poor organisation. Management may see a problem of manufacturing costs and start a cost reduction drive; the real problem may well be poor engineering design or poor sales planning. Management may see an organisation problem; the real problem may well be lack of clear objectives." Therefore the symptoms and symptomatic diagnosis cannot be considered as solutions, but they should be integrated with other tools to provide simplicity for the main task: problem solving.

EXHIBIT 5.3


NON-FINANCIAL SYMPTOMS
Finance
e.g.: outdated financial reports; delay in payment to suppliers & workers
Organisation
e.g.: Low morale Obscure authority & responsibility lines
Research & Development
e.g.: frequent design changes, poor innovation records
Marketing & Sales
e.g.: Poor service & distribution, many customer complaints
Administration
e.g.: Poor communication, Poor co-ordination
Production
e.g.: Reworking of products, Too much attention on big project
Personnel
e.g.: High labour and management turnover, Absenteeism, Overmanning
Top Managemen
& Board
e.g.: one-man rule, policy clashes composition of board

EXHIBIT 5.4

* = Symptoms
- = Causes

5.20 Process of Failure (Dynamics of failure)

As companies grow and expand with their old systems, they are confronted by difficulties which require 'change'. The study of large failed companies evidenced that the company in general and top management in particular fail in a proper assessment and appraisal of change. The need for change is not recognised, the areas of change and the strength and weaknesses are not identified, even if these have been carried out there is no planning for change and the response to it might be a total resistance, poor and inadequate response or ignorance. It is amazing that some major companies who have properly responded to change, fail to control it through an efficient monitoring and review of the process. These all develop weak organisational structure and systems of which the existing 'value system' applied in the selection of the board's members, becomes inadequate, unflexible and obsolete. A poor value system means careless selection of a Board of Directors with the familiar signs and defects such as one-man rule, unbalanced skills, non-participant and yes-sir type of members and lack of management depth. This board elects the chief executives. Sometimes the responsibilities of chairman and chief executive are given to one person, which is unadvisable. Chief executives and the board become the origin of most causes of failure. They are responsible for all top decision making, top decision approval and review of major policies and strategies. They do not carry out their functions and duties properly, the reports are not dealt with, the breach of duties becomes popular. The problems and weaknesses are not identified or wrongly identified which gives rise to more weaknesses. The communication and information system become practically inefficient or idle. Unjustified decisions in launching a new product, a big project or diversification into a new market and process or reckless and ill-thought programmes of

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5.21 Change Appraisal

It is said that "The powerful cause change, the foresighted anticipate it, the clever profit by it, and the inadequate are engulfed by it."(3)

Changes due to internal and external causes are inevitable and the way in which they are handled is vitally important. The problems of change must be fully considered by management, who must accept responsibility for the introduction of changes. Handling of change cannot be solved without the people concerned. It is no secret to anyone that change breeds and multiplies new changes in its wake, as the rate of change accelerates, the need to master its impacts becomes increasingly crucial. As R E Levison states(99) "In the past decade alone we have seen so much disorientation and stress triggered by change that the term 'Future Shock' is passe. What was once future shock is now present shock and present shock is the panic of change."

To dig out the impact of change on failed companies and the survival of existing organisations one needs to clarify the scope and types of change. One of the weaknesses of previous authors who have referred to 'change' as a factor or cause of business failure is that they confined the whole problem only to the lack of response to change , while as the author understands this could be one element of change. The author has classified the change appraisal of companies into the following categories and items where each category must be faced with familiar questions: "What, Why, When, Where, How, Who" at any time.

5.21.1 Recognition and identification of change

Many companies fail to recognise the need for change. They fail to explain why the change should be implemented, companies ignore the important factor of 'time to change', or the 'area' where change is needed.

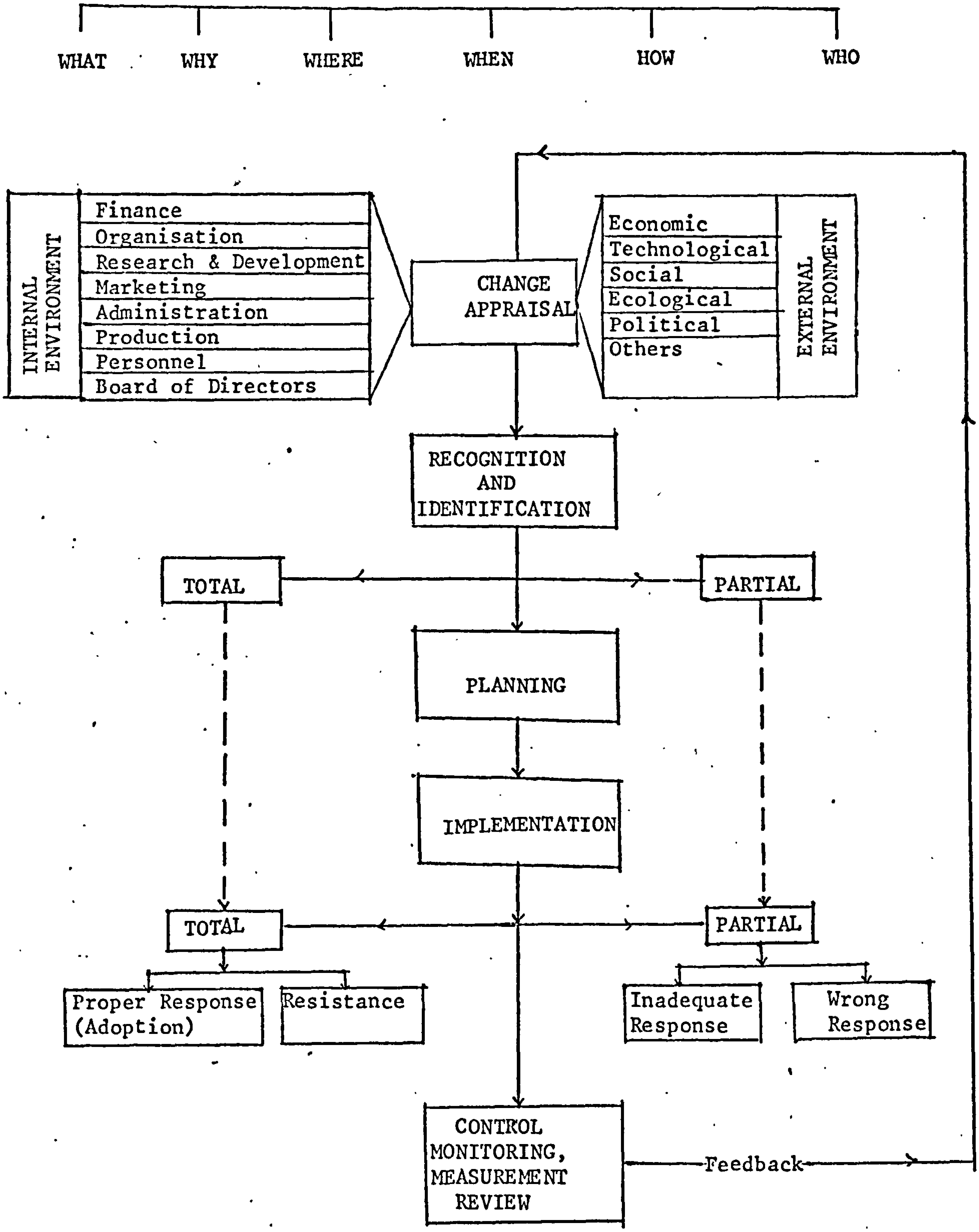


Exhibit: 5.5 COMPANY CHANGE APPRAISAL

They do not find the proper answers for methods and procedures for carrying out the change, and even if they are prepared for change, the failure is inevitable once the responsible person for this important job has not been thought of. In the identification stage, one needs to ask:

What are the objectives of the change ? (short and long term)
What needs to be changed
What kind of change is required
What are the requirements for implementation of change
What are the problems, risks, threats, weaknesses and strengths
What are the human problems
What are the effects of change on organisation and people

How should we approach the change
How to reduce the panic of change
How to manage and control the change
How to overcome the problems and resistance
How to introduce and implement
How fast should the change be implemented

Where is the area of change
Where should the major changes take place
Where is the best market to go into

Why are we changing the present things
Why do we need to change
Why should the company invest, diversify, go abroad

When is the right time to introduce change
When is the best time to expand the business

When is the appropriate time for starting any section of product/market matrix

Who is in charge of monitoring and control of change

Who is responsible for appraisal of change

Who is in charge of planning and control

The role of departmental manager, engineers, accountants, ...

5.21.2 Planning of change

Having answered all aspects of questions concerning the internal and external environment of the company, recognition of the needs, identification of requirements and possible problems of change, management can draw conclusions based on the positive, negative factor and the questions for which there were not answers. The next step is the planning of change where it should be carried out with the intention to benefit the company and people involved. It will help to decide what actions to be taken in introducing the change for optimum reaction at the right time and cost. There should be some norm or criteria for measuring the implementation of change.

5.21.3 Implementation of Change

The implementation of change can be divided into partial and total, depending on how effectively management has been able to recognise and identify the change. A total implementation means either to a proper response to change and adaptation or a total resistance to it, which means the tendency to protect the past and sometimes the traditions. Partial implementation of change is broken into three possible responses:

a) Inadequate response due to a partial identification and recognition of change,

b) Wrong response due to lack of clarity of needs

c) Ignorance, which represents the irresponsibility of management.

5.21.4 Control of change

Having implied the change, there should be a control system to monitor, review, measure and feed back the results for re-appraisal of the change with all its aspects.

It should be noted that control does not mean to resist change, but to harness the change. It is necessary for a company to objectively look at the direction in which it is actually going and compare this with the direction it should be going. It is the author's view that the "change appraisal" chart can be used also in identification of risk and causes of failure. It is noteworthy to consider all aspect questions in each stage and co-ordinate them in a proper form with a clear line of authority and responsibility. The author believes that appraisal of change, risk and company in general must be carried out by all divisional managers, as well as top management.

5.21.5 Types of change

It is said that "while change may be grist to the mill of the opportunist or a signal for the founding of a new business, it may also foreshadow the collapse of institutions. It is not only the object but the swirl of changing circumstances that can create or destroy relevance and value."(3) Companies rarely fail because of one cause, since inadequate management usually makes more than one error. There are many typical occasions where inadequate appraisal of change and poor monitoring and control of change have been major factors in failure of big companies. It is believed by the authors(22) that "there are two types of change which can be described as 'reactive change' and 'initiated change'. Reactive change occurs when events are allowed to overtake the activities concerned and changes must be made to deal with these events. Such changes normally caused by events such as take-over, unplanned moves in business, changes in senior management, introduction of computers and system failures. Initiated change is totally different and is much easier to handle. The very nature of initiated changes, i.e. changes developed to improve existing situations or to meet future needs, is such that careful planning and control of the changes avoids many of the associated problems."(22) The author is of the opinion that although each type affects the other one, the failure of the companies studied was mainly due to 'reactive change' with many examples of changes caused by acquisition, diversification and expansion of companies. Rolls Royce, Handley Page, Mitchell Construction, Court Line and other groups and companies failed because they did not recognise the needs and requirements of change, and lacked an accurate and fast response to it. In the majority of cases lack of proper appraisal of change developed a situation in which the value system applied in the selection of the board's members became obsolete.

5.22 Poor Value System

It is said that "the bottleneck is at the head of the bottle. No business is likely to be better than its top management."(57) In large companies, the Board composed of executive management men is considered as the functioning organ of the enterprise, but it cannot and must not be the governing organ. It is "an organ of review, of appraisal, of appeal, and only in a crisis it becomes an organ of action in order to remove existing executives that have failed, or to replace executives who have resigned, retired or died. Once these have been made, the Board again becomes an organ of review."(57) However, to obtain real benefit from the Board its memnership must be carefully selected. The selection of the Board's members is based on the value system applied in companies. The author believes that this value system constructs the root causes of failure in many large companies examined. C. Robinson(123) who heads one of the largest management consultancy groups, comments "the Board and its membership is the key to the industrial success and survival not merely of individual companies but of British industry itself." He also refers to the possibility of training and developing the directors and concludes "the problem has more to do with the value system applied to a board appointment. A seat on the board as a reward for line or functional management skills and endeavour may not be the best way to produce directors for the company. It is too often the British way."

The value system is a system within which the decision has to be made. The values may be morale, cultural, company goals or accepted principles of company structure. The promotion of people, especially in large organisations, must be studied carefully and carried out properly. A poor value system might stimulate the management to promote or recruit those who conform to their own prejudices. This may also cause management to ignore the fact that "Your staff reinforce you in your error."

There is evidence for companies without a flexible and adequate value system with a board consisting of devil's advocates who make policies and take decisions without even elementary understanding what business is.

A poor value system means, as Cohen quotes, "employing a few people with whom you lack empathy for the sake of achieving a more balanced management team".(44)

Lack of a proper value system means careless selection of a board of directors with all the familiar defects such as: one-man rule, unparticipant management and board, unbalanced top team and lack of management depth. One can easily understand that for the origin of most causes of failure and roots of problems, it is necessary to look at the value system applied. Promotion decisions are what Peter Drucker calls "Life and Death" decisions. He believes "the promotion system should bring about full utilisation of the managerial resources; it should not be entirely from within, the bigger the company, the more desirable is the outsider. The system must ensure that everybody who is eligible is considered and not just the most highly visible people. Nothing does more harm that the too common practice of promoting a poor man to get rid of him."(57) C. Handy, Professor of Management Development at the London Graduate Business School, believes that "In Britain we tend to promote and reward the traditional line managers appointing them ultimately to the board. They are in the main 'energy men' too often with a narrow functional or operational base. Some make superb directors but the conventional board system ascribes little value and affords little opportunity for progress to the thinkers within an organisation the 'wisdom men'."(73) The analysis of the big company crashes by the author provided evidence of the problems and difficulties experienced by these companies due to the existence and application of inappropriate and poor value system. The effects and symptoms of this underlying cause were classified by the author into the following headings:

1. Unbalanced team
2. Non-participant board
3. Lack of management depth
4. One-man idea

Poor Board of Directors

5.23 Weak Top Management Team (Board of Directors and Chief Executive)

An inadequate change appraisal develops a poor value system which selects a board composed of incompetent members with the existence of or tendency towards unbalanced skills, non-participant members, lack of management depth and finally a dominant and sometimes brilliant man whose idea is never opposed by the board's 'Yes, Sir' men. This board of directors was the origin of most causes of failure in companies studied. A review of the duties of the board can explain clearly how important and crucial their jobs and decisions were in the collapse of well-known corporations. These duties can be summarised as follows:

1. The approval of the decisions "what the company's business is" and "what it should be".
2. Approval of measurements to judge the progress towards these objectives.
3. Approval and examination of major strategies and policies.
4. Appointment and dismissal of chief executive.
5. Delegation of authority to chief executive for managing the company's affairs.
6. Decisions concerning capital investment policy and its managed expenditure budgets.
7. Profit planning
8. Responsible for organisational problems and spirit as a supreme court
9. Promotion and reward to managers
10. Management of crisis and risk
11. Requiring financial and operational information
12. Auditing and control of crisis and problems and decisions taken
13. Succession of executives
14. To control the chief executive (considering that delegation does not mean abdication)

One may conclude from these items that the main functions of the board of directors are:

Top decision making

Top decision approving

Top decision reviewing

The analysis of failed companies revealed that failure started from the top where management failed to do its job properly. Having put the emphasis on top management as the main cause of failure, one must be clear about what is 'top', 'senior' or 'middle' management. J. Kerr(95) in a comment on different levels of management states "Inevitably such terms cannot have an absolute meaning - what constitutes a senior management job in a small firm could be a middle management job in a large organisation. In general, top management refers to the people at the very top of an organisation, whose primary concern is with the long-term future, e.g. 'where is the company going in the 1980s' type of question. Senior management is responsible for formulating policy within the guidelines of top management and have overall responsibility for implementing it, one key feature of senior management therefore is the policy making role with a fairly long time horizon." He also refers to middle management and junior management and quotes "middle management is mainly to implement policy but he also shapes the way the policy is implemented and becomes the subsidiary policy maker which affects many people at ground floor level. Junior management have got a supervisory role and their views should be fed back to the policy maker."(95)

Having clarified the distinction between different levels of management, the author maintains his previous view that failure in large companies starts from the top where the board of directors and chief executive are responsible for top decision making and approval such as investment decisions and major strategic changes. It is the author's view that one can divide the management activities and responsibilities into three broad headings as follows:

a) strategic (top management)

b) managerial (senior management)

c) operational (middle and junior management)

Considering these classifications, the failure mainly stems from strategic (top management) and sometimes from managerial (senior management) level. It is rarely due to the third level.

5.24 Investment Strategy

Investment strategy, which is used in this study in a broad context, means the decisions and policies for extension and expansion of company activities, market share and growth. Different ways of increasing business brings problems for management, its support staff and company's survival. Choice of strategic focus depends primarily on market growth potential, market structure and company's available resources; cash, management ability, etc. The success or failure at this stage depends on the ability of management "to know the company's strengths, to adapt to strategic and structural change and to screen all new ideas before making major commitments."[6] It should be noted that strategic change means "a shift in the product or service mix produced by the firm and/or the markets to which it is offered. A key step in the shift is the discovery of a product-market idea."[7] The problems of extending business activities is concerned as much with the direction to take as with the way to do it. Figure 5.6 indicates the broad alternatives as:

MARKET	PRODUCT: EXISTING	PRODUCT: NEW
Existing	Market Penetration (expansion) (very rare cause of failure in large companies studied)	Product Development (Innovation) e.g. Rolls Royce, Handley Page, Court Line, Blanes Ltd, Vehicle and General, John Willament
New	Market Development (Exploration) e.g. Court Line, Mitchell Construction, Vehicle and General	Diversification (Acquisition) e.g. Rolls Royce, Court Line, Mitchell Construction, Handley Page, Vehicle and General, John Willament, Roadship Ltd.

EXHIBIT 5.6 - Investment Alternatives

5.24.1 Market penetration (expansion)

This is the approach which seeks to sell more of the existing product line to the same market and denotes a growth direction through the increase of market share for the present product. The problems which arise are mainly concerned with promotion, distribution and pricing of products. This might be the cause of failure in young and small businesses.

5.24.2 Market development (exploration)

In this stage the company is seeking new mission (needs for existing product) for its product or one can explain briefly as "seeking new markets for present products."

The example of failure in market development can be seen in Court Line, Mitchell Construction, Vehicle and General. The main cause of failure is lack of experience and familiarity with overseas markets.

5.24.3 Product development (innovation)

This can be explained by creation of new products to replace current ones or "developing new products for existing markets." There is evidence in the analysis of failed companies such as Blanes Ltd., Rolls Royce, Handley Page, Court Line, Vehicle and General, John Willament where they failed to overcome their weaknesses in marketing, research and development and production and ignored a proper study of their products life cycle on time.

5.24.4 Diversification and acquisition

This approach represents developing new products for new markets and can be explained as "a combined approach of innovation and exploration with all the problems of each and a few extra ones of its own."[23] The risks are substantial and the rewards can be large. The main problem for the companies examined was not whether to diversify, but how to do it successfully. This is the author's view, that in large companies diversification decision can be considered as 'life and death' decisions. Nearly all the companies studied were struck by the shock of their failure in entering into new products, new markets, new process and new service. RB211 a new product for a new marker in America, Jetstream of Handley Page, Kariba power station in Zaire of Mitchell Construction, Court Line acquisitions in different parts of the world without any experience, Vehicle and General acquisitions such as Pioneer, Marina and Havant Quay projects of J. Willament, merger with J & H and acquisition of companies from British Oxygen Co. Ltd of Roadship Ltd and many other examples maintain the approval of significance of diversification in causing company failure. This approach requires an accurate blend of company's competitive strength, financial, marketing, technical, service, management ability, and a proper analysis of market potential. The major cause of failure in this stage stems from a total lack of understanding their strengths and weaknesses in every aspect especially of the product and market they are intending to diversify. They forgot that any attempt to diversify with existing inexperienced resources is doomed to failure. Diversification is sometimes achieved through take-overs or mergers where companies in related fields come together.

Having considered different approaches in extension of businesses and giving examples of failure, it is important to note "that before any idea becomes a part of the firm's product-market portfolio several steps must be taken: enough information must be developed to convince management of the profitability of the idea, organisational competence must be developed for manufacturing, distributing and marketing the product."(6)

The failed companies lacked an adequate information system with a poor communication and control which caused unjustifiable acquisition, expansion and extension based on guesswork estimates and assessments.

However, investment strategy decisions are taken and approved by the board of directors and it is an overriding issue in marketing which must be carefully studied. It is a usual cause of failure among companies favoured with the exceptional capacity to borrow money.

5.25 The Late Symptoms

One striking factor about the companies studied is that until they actually face with the final collapse, everybody goes about exuding confidence without giving any hint that a crisis is developing. This is represented by too optimistic reports and comments by the chairman, managing director and other members of the board and even by pouring more and more money into ailing companies. They pretend to be confident about the health of the company while in reality the main reason is to avoid the announcement of difficulties and to prevent the impact of losing confidence in business community. Obviously, there is sense in that, but "too often there is a sneaking suspicion that the management does not want to face up to its own responsibility for allowing a crisis to develop. So a dangerous situation is allowed to drift into a worse one, which positive action might have averted. Even more disturbing, perhaps, is the growing evidence that senior executives often fail to recognise crisis symptoms which, with hindsight, seem almost absurdly obvious."(3)

5.26 Conclusions

Having analysed the large company crashes in recent years, one has to come to conclusions by asking the ultimate question which arises, namely: "why the companies fail ?". The short answer is that there is no single reason for the collapse. It is caused by a number of contributory factors during a gradual process and relatively long period, depending on the size of the company and type of industry and its ability to borrow money from the public, shareholders and government. Although the causes are numerous, they fall readily into two broad classes: (1) internal: those which represent the quality of the management, and (2) external: those which come from outside the individual business. The total collapse of an organisation is invariably caused by fundamental errors in management and rarely to mischance or unexpected events, in other words the causes of failure in large companies are more internal rather than external factors.

In the majority of cases the process of failure starts because of a misconceived attempt to cause change without a proper recognition of needs and identification of risks, inadequate planning for change and response to it and most important failure to monitor and control the change. For the origin of most causes, however, one must look at the board of directors where crucial decisions relating to major policies and strategies of the firm are taken, approved and reviewed. In the analysis of company failure, the board can be considered as the reservoir of problems and the most important area of risk. It is said that the strength of any organisation depends on the soundness of its foundations and the correctness of its basic structure. Yet the present study found that the companies are often built on foundations so shaky that there are crashes and disasters which threaten the business community and the national economy. It is noteworthy that corporate planners can benefit from an awareness of the causes and symptoms of company failure because they are often called to advise their company on acquisition candidates and one reason for offering a company for acquisition is that it is failing. Management should be alert for signs of failure. Creditors should not be ignorant of some non-financial symptoms. The lessons of failure are as important as the recipes of success.

The conclusions drawn from this chapter can be listed as follows:

1. Company failure is a gradual process which takes many years. The period depends on the severity of problems, the size of the company, management ability in raising money from the public or government and some unexpected external factors.
2. The major causes of failure come from internal environment of the company. (All the companies studied).
3. The board of directors is the main risk area where most of the problems are shaped. This was also a common factor in all the cases studied.
4. Financial problems are mainly the symptoms of underlying managerial weakness. Some of these symptoms become secondary causes in later stages.
5. There was a gap between production and marketing organisation of failed companies. e.g. Rolls Royce, Handley Page.
6. Inflation, recession and economic climate of recent years have accelerated the failure, but not a major causal factor.eg.(Court Line, V & G)
7. Lack of a proper change appraisal is a major cause of company failure.
8. One-man rule, unbalanced team, unparticipative board and even management gap are the signs of a weak board of directors. This itself is the effect of a poor value system in the company. (Most of the companies)
9. Poor communication was a common weakness in almost all the companies studied. e.g. John Willament, Court Line, Vehicle & General.
10. Another common feature of failure of companies is too optimistic

profit forecasts, misleading and unjustified chairman's statements and manipulated accounts when the company was in trouble. (All companies)

11. The large companies do not fail because of a complex system, but from a total lack of understanding and knowledge of the very basic principles.

12. The type of industry and business does not seem to be an important factor, although the risks associated with manufacturing industries are greater than others.e.g. Handley Page and Rolls Royce.

13. Considering the three levels of management responsibility (strategic, managerial and operational), the failure often stems from the first level, strategic and in some cases it is accompanied by managerial level.

14. The causes and symptoms of failure for old and public companies are often different from the young and small businesses. There may be some common contributing factors in both cases.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this chapter is:

a) To summarise the main conclusions that have been inferred during the course of the present study

b) To suggest areas and topics for further research.

6.1 Conclusions

The summary of the study, data and main conclusions are as follows:-

1. During the period 1970-1977, a total number of 390,985 new companies were registered and 310,489 companies were dissolved, struck off and notified in liquidation.

2. On average, one-fourth of all liquidations notified during the period of study were manufacturing companies. A peak level was reached in 1976 when 1319 companies failed. Of these, 419 companies were in metals and engineering group, representing the highest number of failure, as defined by the Standard Industrial Classification.

3. On average, approximately 50% of all notified liquidations were members' voluntary liquidations, 30% creditors' voluntary and 20% compulsory liquidations.

4. The empirical results obtained in the course of this study supported the conclusions reached by previous researchers, that the longer a company survives; generally other things being equal, the smaller becomes the probability of failure.

5. 28% of the companies that fail, fail in the first three years, 47% in the first five years and nearly two-thirds in the first ten years; with

only one-third of companies surviving beyond ten years.

6. Electrical Engineering corporations have the highest infant mortality, while textiles companies possess the highest late failure rate and have the longest lives.

7. Considering the failure statistics of companies according to the year of failure (1970 to 1977), the period 1973 to 1975 gives the highest early-age failure indicating that the economic climate of this period which was characterised by inflation, three-day week, oil crisis, etc., had significant impact on young and small businesses.

8. The mixed-Weibull distribution was found to be a particularly appropriate model for describing the different stages of failure in a company life cycle.

9. Log-normal, Gamma and Weibull distributions whilst also adequate to described the failure behaviour of companies, are marginally worse than the mixed-Weibull distribution.

10. The values of the parameters of distributions describing company failure, indicate a common failure behaviour of those companies for the period studied.

11. Simple Weibull scale parameter of 125.6 months indicates that 63.3% of companies fail before achieving an age of 10 years.

The following conclusions, derived from qualitative data relating to large companies indicate:

12. There is no single reason for the collapse of companies. Failure is caused by a number of contributory factors during a gradual process over a relatively long period.

13. The majority of significant causes are internal and arise from fundamental errors in management,and rarely to mischance or external factors.

14. Considering the levels of management activities and responsibility, the failure often starts from the top where strategic decisions are, or should be, taken.

15. With regard to different areas of activity, the board of directors is the main source of problems and mistakes.

16. The unstable economic conditions of recent years have, in the cases studied, only accelerated the failure process but have not been a major causal factor.

17. As non-financial symptoms are rarely concealed, these can readily provide important information regarding the 'health' of the company.

18. Financial difficulties are the symptoms of underlying weaknesses which can become significant secondary causes during the process of failure.

19. Awareness of causes and symptoms of failure can provide significant guidance for corporate planners and policy makers.

20. More attention should be given to the 'value system' of companies and selection of the board of directors.

21. Appropriate change appraisal systems can avoid many problems and failures.

22. Companies do not fail because of complex structure, but because they ignore the basic principles of good management.

6.2 Recommendations for Further Research

1. Further analysis of the financial symptoms of company failure using ratio and trend analysis to identify the financial patterns of failure.

2. Development of diagnostic models based on financial and non-financial symptoms.

3. An investigation of 'success' factors of companies and evaluation of success and failure causes using statistical methods, e.g. factor analysis.

4. Application of the results of the present study to the development of possibly more accurate Z models.

5. Investigation of the impacts and consequences of company failure based on classifications given in the present study.

6. Study of business reorganisation as a possible remedy for present high failure rate. This to include development of rescue and turnaround strategies.

7. An integration of prediction models, causal and symptom diagnosis to develop an efficient tool for management and other interested groups for 'health' auditing of the company.

8. Assessment of existing financial and non-financial prediction models, to identify their strengths and weaknesses.

9. Development of some preventive models in order to reduce the number of failures and the consequences of collapse.

APPENDIX A

DATA BANK

A.1 Classification Used

The classification used in collection of data is based on the Standard Industrial Classification (SIC). SIC is based on industries and not on occupations and without regard to who owns or operates. The classification is arranged in a list of industry headings which are called Minimum List Headings (MLS). The headings of related industries are grouped into orders.

For the purpose of this classification the unit taken is the 'establishment'. An establishment is the smallest unit which can provide the information normally required for an economic census, for example, employment, capital formation, turnover etc. Usually the principal activities carried on in an establishment fall within a single heading of the classification (e.g. steel making or sugar refining). Frequently, distinct activities characteristic of different industries are carried on at one address, e.g. cotton weaving and making up of household textiles, but normally these are not classified separately and the whole establishment is classified according to the main activity.

Some special points should be mentioned namely:

a. Repair work

Most kinds of repair work are associated with activities which are classified either to manufacturing or to distribution and in these cases the underlying principle of classification is that where the bulk of the repair work on goods of any particular type is carried out by manufacturers, any establishment specialising in the repair of these goods are classified to manufacturing. Where, however, most of the repairs are carried out at establishments whose main business is distribution, the specialist repair establishments are also classified to distribution. Thus, establishments repairing radio and television sets, watches and clocks, furniture, etc. are classified to the distributive trades. Establishments engaged in the repair of ships, locomotives, aircraft and most kinds of plant and machinery are classified to manufacturing industry. The repair works such as motor, boot and shoe repairing are treated as Miscellaneous Services.

b. Installation work

The installation of machinery, equipment etc. is an activity which is normally carried out by an establishment having a different major activity which decides its industrial classification. Where, however, installation is the only, or major, activity of a separate establishment, it should be classified to an appropriate heading, as

Construction: installation of integral parts of the building, e.g. heating and ventilating system.

Distribution: domestic washing machines

Manufacturing: the installation of plant and machinery e.g. a computer, a telephone exchange system.

The Standard Industrial Classification for the manufacturing industries consists of 119 Minimum List Headings which are distinguished by Arabic numerals. These Minimum List Headings have been grouped into 16 orders which are distinguished by alphabetical characters (A to U). A brief description of the main industries is given below the title of each heading. Gaps in the sequences of numbering the headings with each order have been left to permit additions to the Minimum List which may be necessary at a later date. A summary of orders and Minimum List Headings in Manufacturing Industries with the number of failed companies in the Data Bank is given in the Tables corresponding to each group.

GROUP A - FOOD, DRINK AND TOBACCO

Minimum List Heading	Type of Business	No. of Failed Companies
211	Grain milling	-
212	Bread and flour confectionery	-
213	Biscuits	2
214	Bacon curing, meat and fish products	9
215	Milk and milk products	1
216	Sugar	-
217	Cocoa, chocolate and sugar confectionery	11
218	Fruit and vegetable products	1
219	Animal and poultry foods	5
221	Food industries not elsewhere specified	10
231	Brewing and malting	3
232	Soft drinks	4
239	Other drink industries	-
240	Tobacco	1

Total number or failures = 47

Sources: 1. Standard Industrial Classification

2. Data Bank developed in the present study

GROUP B - COAL AND PETROLEUM PRODUCTS

Minimum List Heading	Type of Business	No. of Failed Companies
261	Coke ovens and manufactured fuel	-
262	Mineral oil refining	-
263	Lubricating oils and greases	1

Total number of failures = 1

GROUP C - CHEMICALS AND ALLIED INDUSTRIES

Minimum List Headings	Type of Business	No. of Failed Companies
271	General chemicals	6
272	Pharmaceutical chemicals and preparations	4
273	Toilet preparations	5
274	Paint	5
275	Soap and detergents	9
276	Synthetic resins and plastics materials and synthetic rubber	2
277	Dyestuffs and pigments	8
278	Fertilisers	-
279	Other chemical industries	5

Total number of failures - 44

Sources: 1. Standard Industrial Classification

2. Data Bank developed in the present study

GROUP D - METAL MANUFACTURE

Minimum List Heading	Type of Business	No. of Failed Companies
311	Iron and steel (general)	16
312	Steel tubes	3
313	Iron castings, etc.	1
321	Aluminium and aluminium alloys	11
322	Copper, brass and other alloys	2
323	Other base metals	2

Total number of failures = 35

Sources: 1. Standard Industrial Classification
2. Data Bank developed in the present study

It should be noted that this order includes smelting, refining and alloying (including steel melting); rolling and drawing, and the production of castings, forgings and other basis forms of ferrous and non-ferrous metals. Drop forging of iron and steel, wire drawing and further processing and fabrication are excluded. The production of precious metals is classified in group L (Metal Goods).

GROUP E - MECHANICAL ENGINEERING

Minimum List Heading	Type of Business	No. of Failed Companies
331	Agricultural machinery (excluding tractors)	9
332	Metal-working machine tools	9
333	Pumps, valves and compressors	1
334	Industrial engines	-
335	Textile machinery and accessories	1
336	Construction and earth moving equipment	3
337	Mechanical handling equipment	10
338	Office machinery	4
339	Other machinery	43
341	Industrial (excluding process),plant and steelwork	54
342	Ordnance and small arms	1
349	Other mechanical engineering not elsewhere specified	143

Total number of failures = 278

Sources: 1. Standard Industrial Classification
2. Data Bank developed in the present study

Note: Establishments specialising in the production of parts of a particular type of machinery included in this group are classified to the same heading as manufacturers of such machinery unless such parts are specifically classified elsewhere

GROUP F - INSTRUMENT ENGINEERING

Minimum List Heading	Type of Business	No. of Failed Companies
351	Photographic and document copying equipment	1
352	Watches and clocks	2
353	Surgical instruments and appliances	4
354	Scientific and industrial instruments and systems	11

Total number of failures = 18

GROUP G - ELECTRICAL ENGINEERING

Minimum List Headings	Type of Business	No. of Failed Companies
361	Electrical machinery	10
362	Insulated wires and cables	3
363	Telegraph and telephone apparatus and equipment	2
364	Radio and electronic components	19
365	Broadcast receiving and sound reproducing equipment	25
366	Electronic computers	2
367	Radio, radar and electronic capital goods	12
368	Electric appliances primarily for domestic use	21
369	Other electrical goods	20

Total number of failures = 114

Source: 1. Standard Industrial Classification
2. Data Bank developed in the present study

GROUP H - SHIPBUILDING AND MARINE ENGINEERING

Minimum List Heading	Type of Business	No. of Failed Companies
370-1	Shipbuilding and shiprepairing	44
370-2	Marine engineering	

Total number of failures = 44

GROUP K - VEHICLES

Minimum List Heading	Type of Business	No. of Failed Companies
380	Wheeled tractor manufacturing	1
381	Motor vehicle manufacturing	26
382	Motor cycle, tricycle and pedal cycle manufacturing	9
383	Aerospace equipment manufacturing and repairing	1
384	Locomotives and railway track equipment	-
385	Railway carriages and wagons and trams	5

Total number of failures = 42

Source: 1. Standard Industrial Classification
2. Data Bank developed in present study

GROUP L - METAL GOODS NOT ELSEWHERE SPECIFIED

Minimum List Heading	Type of Business	No. of Failed Companies
390	Engineers' small tools and gauges	15
391	Hand tools and implements	13
392	Cutlery, spoons, forks and plated tableware	3
393	Bolts, nuts, screws, rivets	3
394	Wire and wire manufacturers	3
395	Cans and metal boxes	2
396	Jewellery and precious metals	21
399	Metal industries not elsewhere specified	90

Total number of failures = 150

Sources: 1. Standard Industrial Classification

2. Data Bank developed in the present study

GROUP M - TEXTILES

Minimum List Heading	Type of Business	No. of Failed Companies
411	Production of man-made fibres	3
412	Spinning and doubling on the cotton and flax systems	9
413	Weaving of cotton, linen and man-made fibres	2
414	Woollens and Worsted	20
415	Jute	-
416	Rope, twine and net	1
417	Hosiery and other knitted goods	16
418	Lace	5
419	Carpets	8
421	Narrow fabrics	5
422	Made-up textiles	12
423	Textile finishing	3
429	Other textile industries	4

Total number of failures = 88

GROUP N - LEATHER, LEATHER GOODS AND FUR

Minimum List Heading	Type of Business	No. of Failed Companies
431	Leather (tanning and dressing) and fellmongering	4
432	Leather goods	28
433	Fur	3

Total number of failures = 35

Source: 1. Standard Industrial Classification
2. Data Bank developed in present study

GROUP P -CLOTHING AND FOOTWEAR

Minimum List Heading	Type of Business	No. of Failed Companies
441	Weatherproof outerwear	1
442	Men's and Boys' tailored outerwear	12
443	Women's and girls' tailored outerwear	69
444	Overalls and men's shirts, underwear	6
445	Dresses, lingeries, infants' wear	12
446	Hats, caps and millinery	6
449	Dress industries not elsewhere specified	160
450	Footwear	11

total number of failures = 277

GROUP R - BRICKS, POTTERY, GLASS AND CEMENT

Minimum List Heading	Type of Business	No. of Failed Companies
461	Bricks, fireclay and refractory goods	14
462	Pottery	3
463	Glass	21
464	Cement	-
469	Abrasives and building materials	17

Total number of failures = 55

GROUP S - TIMBER AND FURNITURE

Minimum List Heading	Type of Business	No. of Failed Companies
471	Timber	22
472	Furniture and upholstery	104
473	Bedding	5
474	Shop and office fitting	70
475	Wooden containers and baskets	12
479	Miscellaneous wood and cork manufacture	26

Total number of failures = 239

Source: 1. Standard Industrial Classification

2. Data Bank developed in present study

GROUP T - PAPER, PRINTING AND PUBLISHING

Minimum List Heading	Type of Business	No. of Failed Companies
481	Paper and board	2
482	Packaging products of paper, board and associated materials	6
483	Manufactured stationery	6
484	Manufacturers of paper and board not elsewhere specified	-
485	Printing, publishing of newspapers	4
486	Printing, publishing of periodicals	22
489	Other printing, publishing, bookbinding and engraving	199

Total number of failures = 239

GROUP U - OTHER MANUFACTURING INDUSTRIES

Minimum List Heading	Type of Business	No. of Failed Companies
491	Rubber	2
492	Linoleum, plastics floor covering, leathercloth	2
493	Brushes and brooms	1
494	Toys, games, children's carriages and sports equipment	30
495	Miscellaneous manufacturing industries	5
496	Plastics products not elsewhere specified	35
499	Miscellaneous manufacturing industries	3

Total number of failures = 78

Source: 1. Standard Industrial Classification

2. Data Bank developed in the present study

APPENDIX B

RELIABILITY ANALYSIS

B.1 Properties of Distributions

B.1.1 The distribution function

When a performance parameter, t, of a system is subject to random variations the actual value of t at any precise point is not known. However such a variate t may be more likely to take on some values rather than others so that the pattern of its occurrence may be expressed in probabilistic terms. The function which describes the pattern or distribution of the values of t is known as the distribution function.

B.1.2 Probability density function

When a variate is continuous the distribution function of basic interest is the probability density function (pdf). If f(t) is a pdf of a continuous variate t, then $f(t)\Delta(t)$ is defined as the probability that values of the variate t fall between $(t - \frac{1}{2}\Delta t)$ and $(t + \frac{1}{2}\Delta t)$. In other words, $f(t)\Delta(t)$ is the limiting ratio of the number of all values of t in the range $(t - \frac{1}{2}\Delta t)$ to $(t + \frac{1}{2}\Delta t)$ to the total number of all possible values of t.

The area under the pdf curve, therefore, represents probability. Hence the probability that t lies in some finite range from a to b is

$$P(a<t<b) = \int_a^b f(t)d(t) \qquad \text{(I)}$$

where a and b represent the extreme limits of all possible values of t, then it is obvious that

$$\int_{-\infty}^{\infty} f(t)dt = 1 \qquad \text{(II)}$$

The normal pdf is an example of a function which has extreme limits of $-\infty$ and ∞. The following are some typical pdf for continuous random variates.

Normal:

$$f(u) = \frac{1}{\sigma\sqrt{(2\pi)}} \exp - \frac{(t-u)^2}{2\sigma^2} \qquad \text{for } -\infty<t<\infty$$

where u is the mean of the distribution and

σ is the Standard Deviation

Log-Normal:

$$f(u) = \frac{1}{t\sigma\sqrt{(2\pi)}} \exp - \frac{(\log t-u)^2}{2\sigma^2} \qquad \text{for } 0<t<\infty$$

Weibull:

$$f(u) = \frac{\beta}{\lambda^\beta} t^{\beta-1} \exp - (\frac{t}{\lambda})^\beta \qquad \text{for } t>0, \ \beta>0, \ \lambda>0$$

Gamma:

$$f(u) = \frac{1}{\lambda^\beta \Gamma(\beta)} t^{\beta-1} \exp (\frac{-t}{\lambda}) \qquad \text{for } t>0$$

Exponential:

$$f(u) = \frac{1}{\lambda} \exp (\frac{-t}{\lambda}) \qquad \text{for } t>0$$

Many of these distribution functions are related to each other. The log-normal is the normal function with the variate expressed logarithmically and the exponential function is a particular case of the Weibull or the Gamma functions.

B.1.3 Cumulative distribution functions

Frequently one is interested in the probability of a failure occurring before some specified time, say t. This probability can be obtained from the relevant probability density function as follows:

$$\text{Probability of failure before time } t = \int_{-\infty}^{t} f(t)d(t)$$

The integral $\int_{-}^{t} f(t)d(t)$ is denoted by F(t) and is termed cumulative distribution function. As t tends to infinity, F(t) tends to unity. The cumulative distribution function of the normal pdf is not capable of simple analytical expression and tables are usually used for its evaluation. Many other pdf's do lead to relatively simple analytical expressions for their corresponding cumulative functions. For instance, in the case of the Weibüll distribution

$$f(t) = \frac{\beta t^{\beta-1}}{\lambda^{\beta}} \quad e^{-(t/\lambda)^{\beta}}$$

$$F(t) = \int_{o}^{\infty} \frac{\beta t^{\ -1}}{\lambda^{\beta}} \quad e^{-(\frac{t}{\lambda})^{\beta}} dt$$

$$= -e^{-(\frac{t}{\lambda})^{\beta}} \Big|_{o}^{t}$$

or

$$F(t) = 1 - e^{-(t/\lambda)^{\beta}}$$

The cumulative distribution function expresses the probability of the value of a variate lying in the range from the lower limit of the variate to some specific value of the variate.

B.2 Maximum Likelihood Method

One of the most commonly used methods of estimating procedure is the Maximum Likelihood Method. This is derived from the fact that the probability of obtaining the given sample values should be a maximum if the estimator equals the population value.

Suppose than t_1, t_2, ..., t_n are n independent random variables, i.e.

with time to failure probability function f(t). We can define

$$L = (\underline{\theta}/t_1, t_2, \ldots, t_n) = f(t_1, \underline{\theta}) \ldots f(t_n \cdot \underline{\theta})$$

or

$$L = \prod_{i=1}^{n} f(t_i, \underline{\theta})$$

where

L is called the joint probability density function of t's but it is called the likelihood function when considered as a function of $\underline{\theta}$ for a given t_1, $t, \ldots t_n$.

θ is the estimator of a population parameter.

To maximise the likelihood function L, the classical maxima and minima are used. In order to find the value of $\underline{\theta}$, to maximise the likelihood function, the following procedure is used:

$$\frac{\partial L}{\partial \theta} = 0 \qquad \text{(I)}$$

$$\frac{\partial^2 L}{\partial \theta_i \theta_k} < 0 \quad \text{gives maximum L} \qquad \text{(II)}$$

Equation (I) is called the likelihood equation and has to be solved by iteration procedure in order to evaluate the parameters.

This method is most efficient for large N (N>30). The application and estimation procedure for different distributions are discussed by Lipow, Tia, Kamath and Isfahani.

B.3 Kolmogorov-Smirnov Test for Goodness of Fit

This test concentrates on the deviation between the observed cumulative histogram and the hypothesised cumulative distribution function F(t).

$$S(t_i) = \frac{i}{N+1}$$

where

t_i is the ith largest observed value in the random sample of size N

The test statistic D_{max} is given by

$$D_{max} = \text{SUP} \left| S(t_i) - F(t_i) \right|$$

or

$$D_{max} = \text{Max} \left| \frac{i}{N+1} - F(t_i) \right|$$

$$-\infty < t < \infty$$

D is the largest of the absolute values of the N differences between the hypothesised cumulative distribution function (CDF) and the observed cumulative histogram evaluated at observed value in sample.

B.4 Failure and Hazard Rate

To understand the failure and hazard raye "one has to consider a test where a large number of identical components are put into operation and the time to failure of each is noted. The failure rate of equipment at time t is the probability that the equipment will fail in the next interval of time given that it is good at the start of the interval; it is a conditional probability"( ) with the usual notation as:

P(A/B) = Probability of event A occurring once it is known that B has occurred = Q(t)

where A is the event "failure occurs in interval Δ(t)"
B is the event "no failure has occurred up to time t"

$$\text{and } P(A/B) = \frac{P(A \text{ and } B)}{P(B)}$$

$$P(A \text{ and } B) = \int_{t}^{t+\Delta t} f(t)dt$$

$$P(B) = \int_{t}^{\infty} f(t)dt$$

$$Q(t) = \frac{\int_{t}^{t+\Delta t} f(t)dt}{\int_{t}^{\infty} f(t)dt} = \frac{F(t+\Delta t)-F(t)}{1-F(t)}$$

Now, if this equation is divided by Δt and Δt approaches zero, one obtains

$$h(t) = \frac{f(t)}{1-F(t)}$$

where $h(t)$ is called the force of mortality, hazard rate or instantaneous failure rate.

The term failure rate is often used when, strictly speaking, instantaneous failure rate should be used.

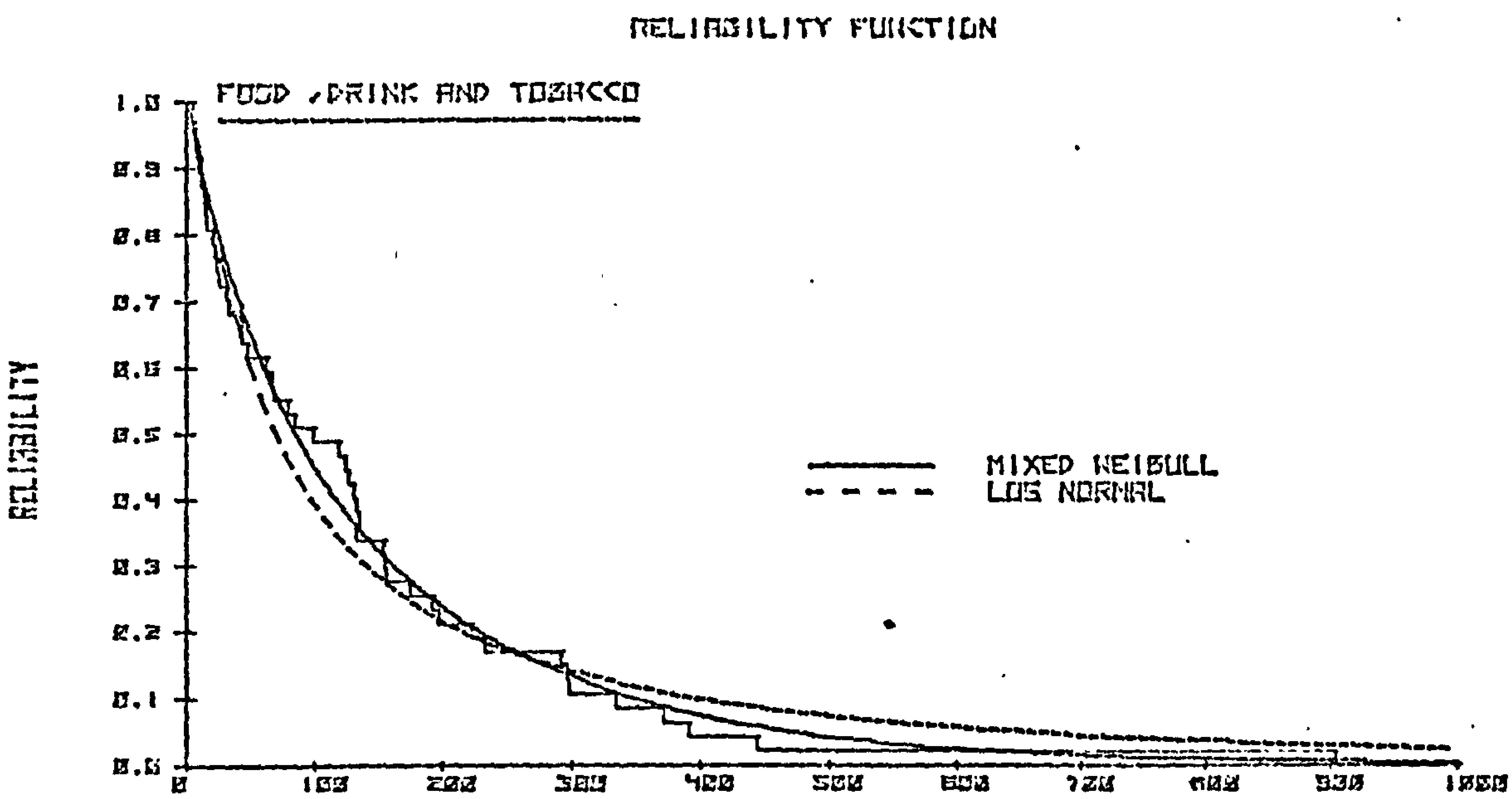

RELIABILITY FUNCTION
FOOD ,DRINK AND TOBACCO
RELIABILITY
MIXED WEIBULL
LOG NORMAL
FAILURE TIME (MONTH)

Fig. B.1

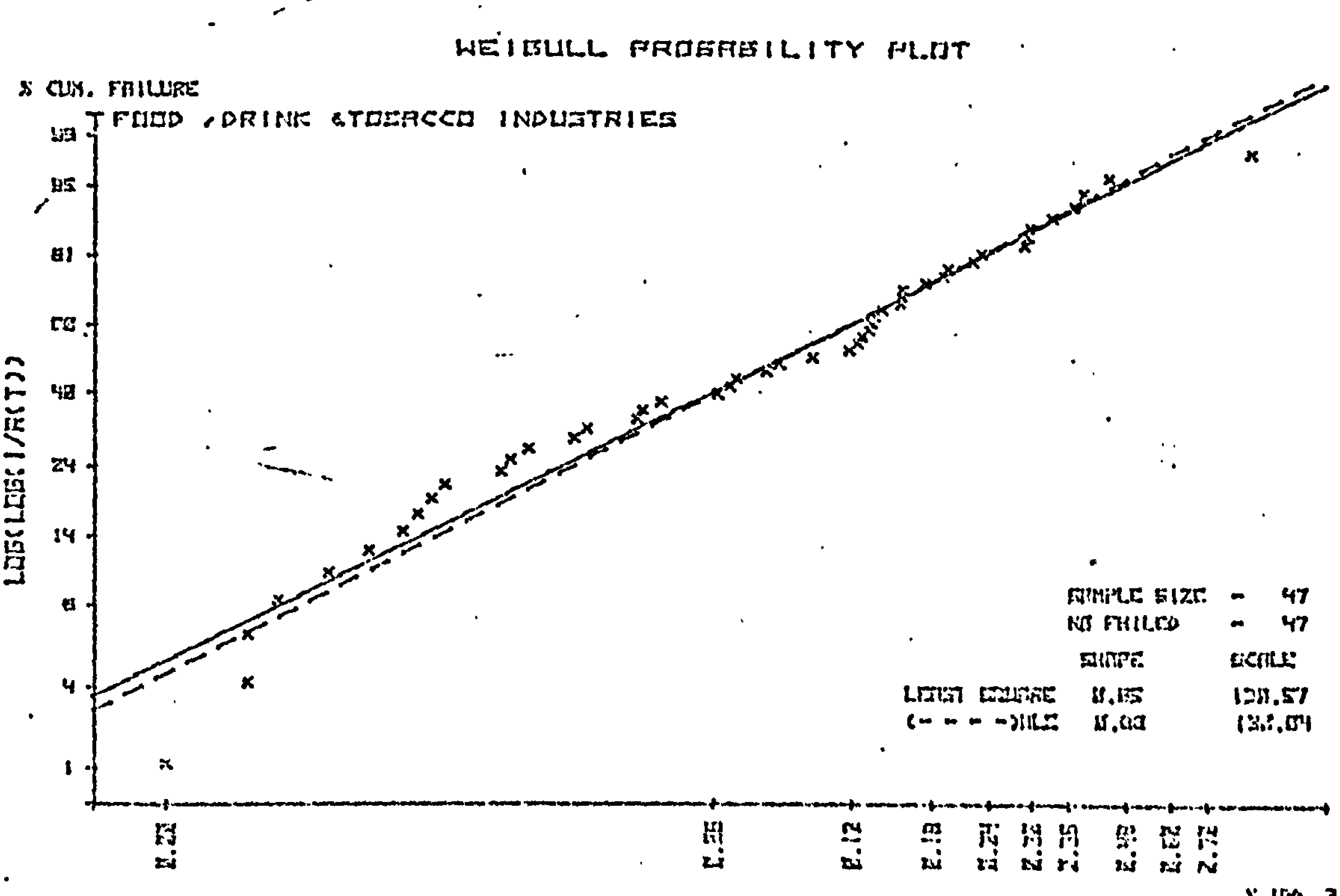

WEIBULL PROBABILITY PLOT
% CUM. FAILURE
FOOD ,DRINK &TOBACCO INDUSTRIES
LOG(LOG(1/R(T)))
SAMPLE SIZE - 47
NO FAILED - 47
SHAPE
SCALE
LEAST SQUARE
(- - - -)MLE
LOG(TIME)

Fig. B.2

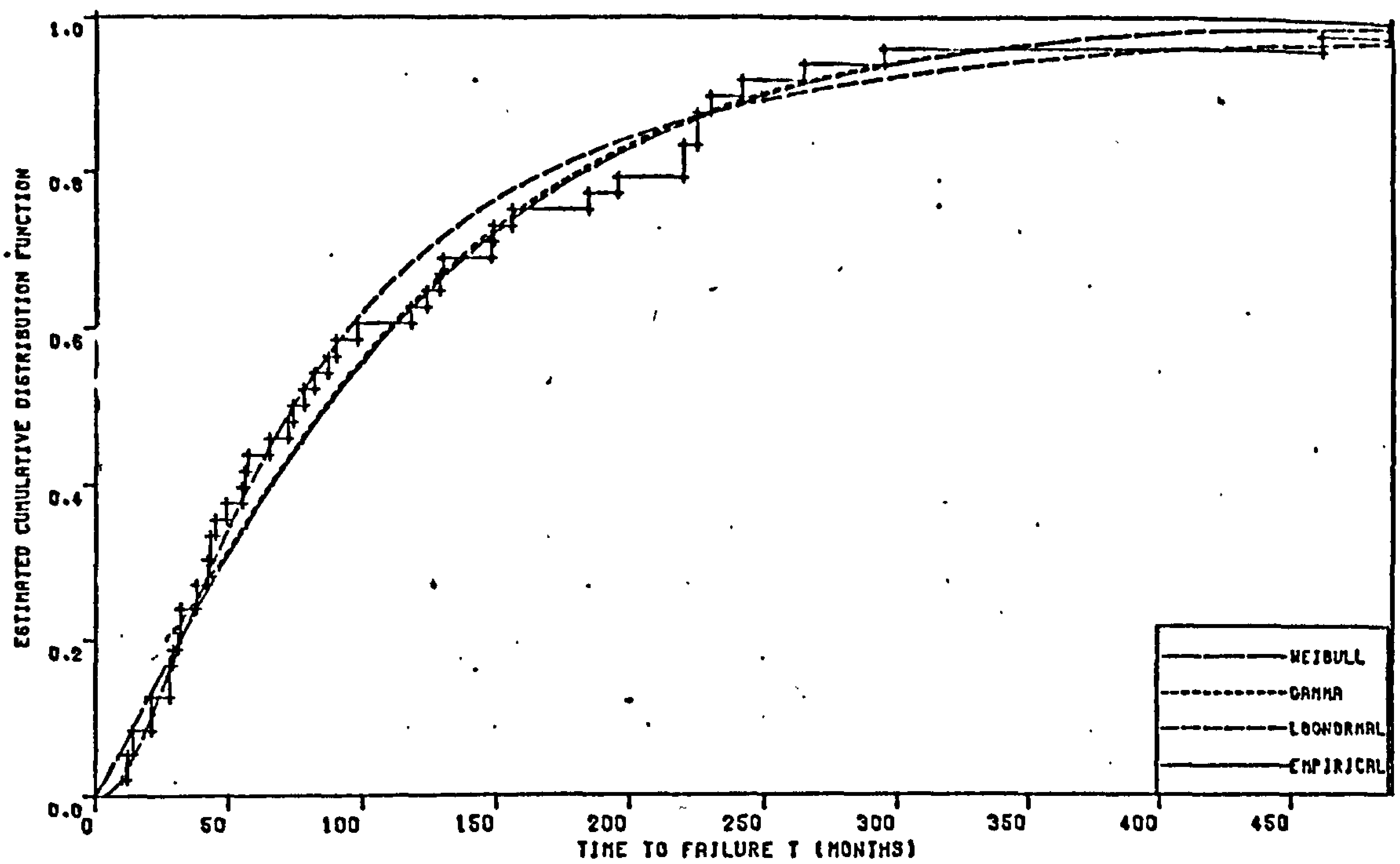


Fig. B.3 FIG : CUMULATIVE DISTRIBUTION FU'CTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

CHEMICALS AND ALLIED INDUSTRIES

	SHAPE	SCALE
LOG-NORMAL	0.99	4.31
WEIBULL	1.12	121
GAMMA	1.11	104

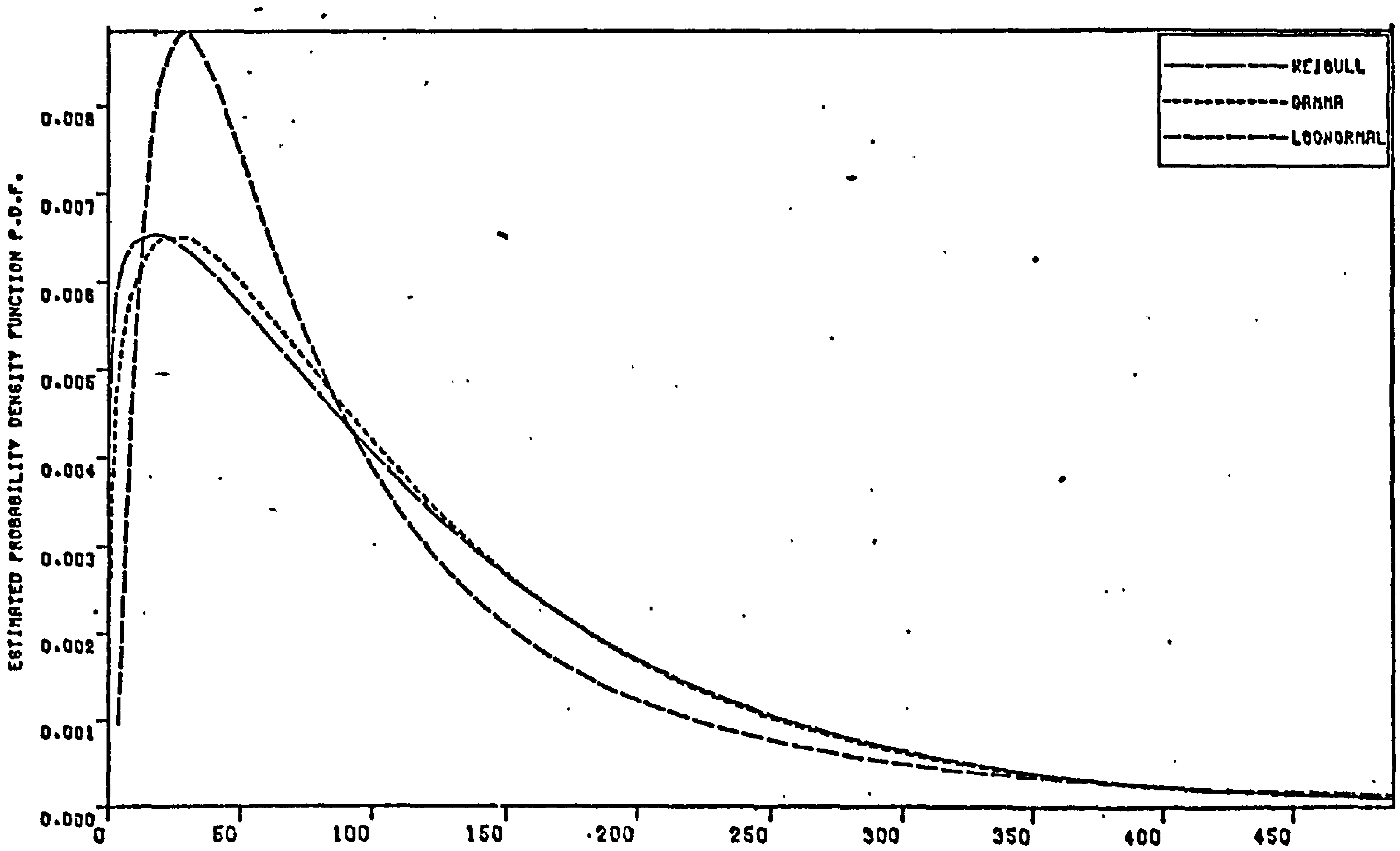


Fig. B.4 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

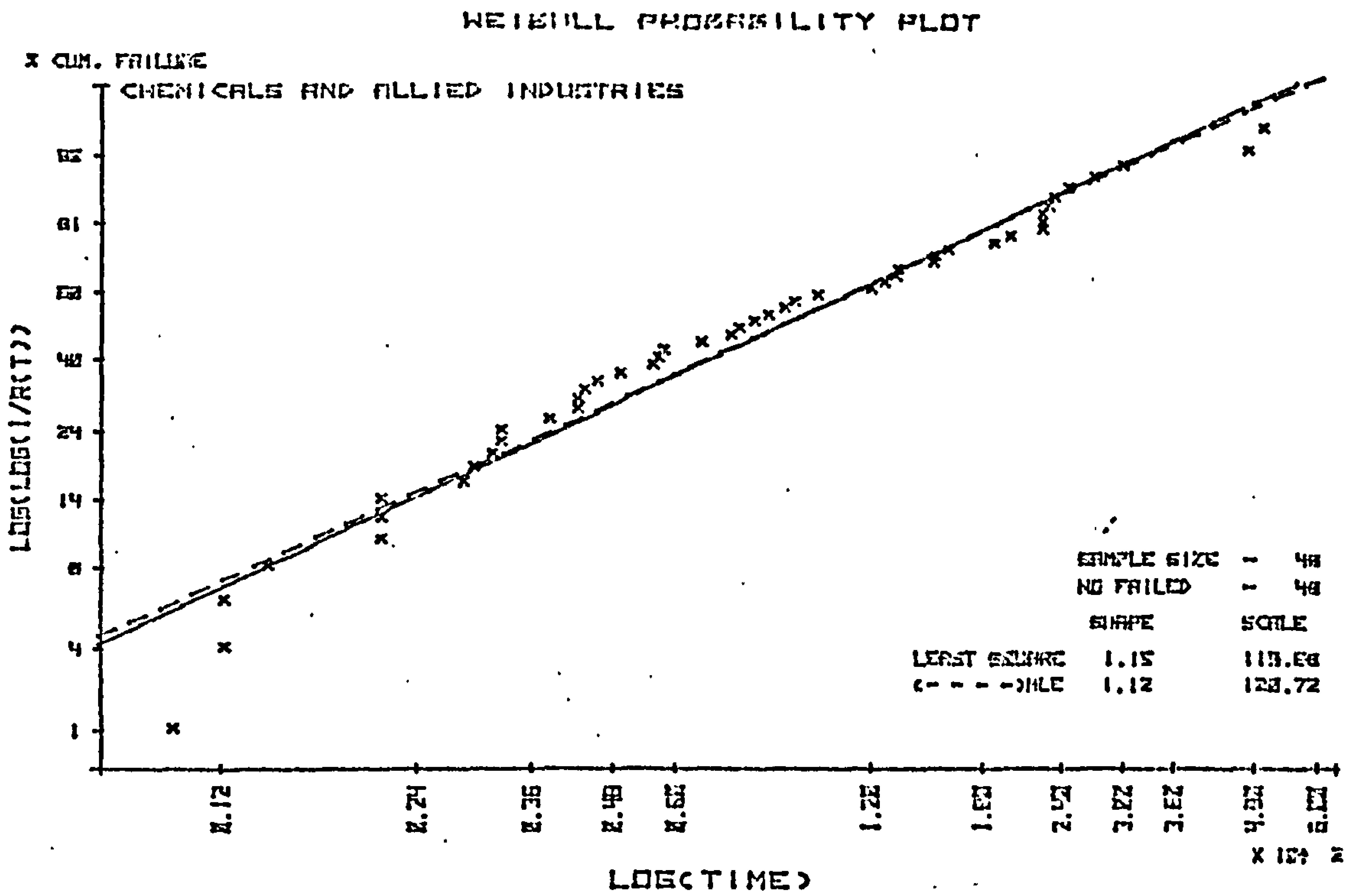

WEIBULL PROBABILITY PLOT
% CUM. FAILURE
CHEMICALS AND ALLIED INDUSTRIES
LOG(LOG(1/R(T)))
SAMPLE SIZE - 48
NO FAILED - 48
SHAPE SCALE
LEAST SQUARE 1.15 115.E8
<- - - ->MLE 1.12 128.72
LOG(TIME)
X 10↑ 2

Fig. B.5

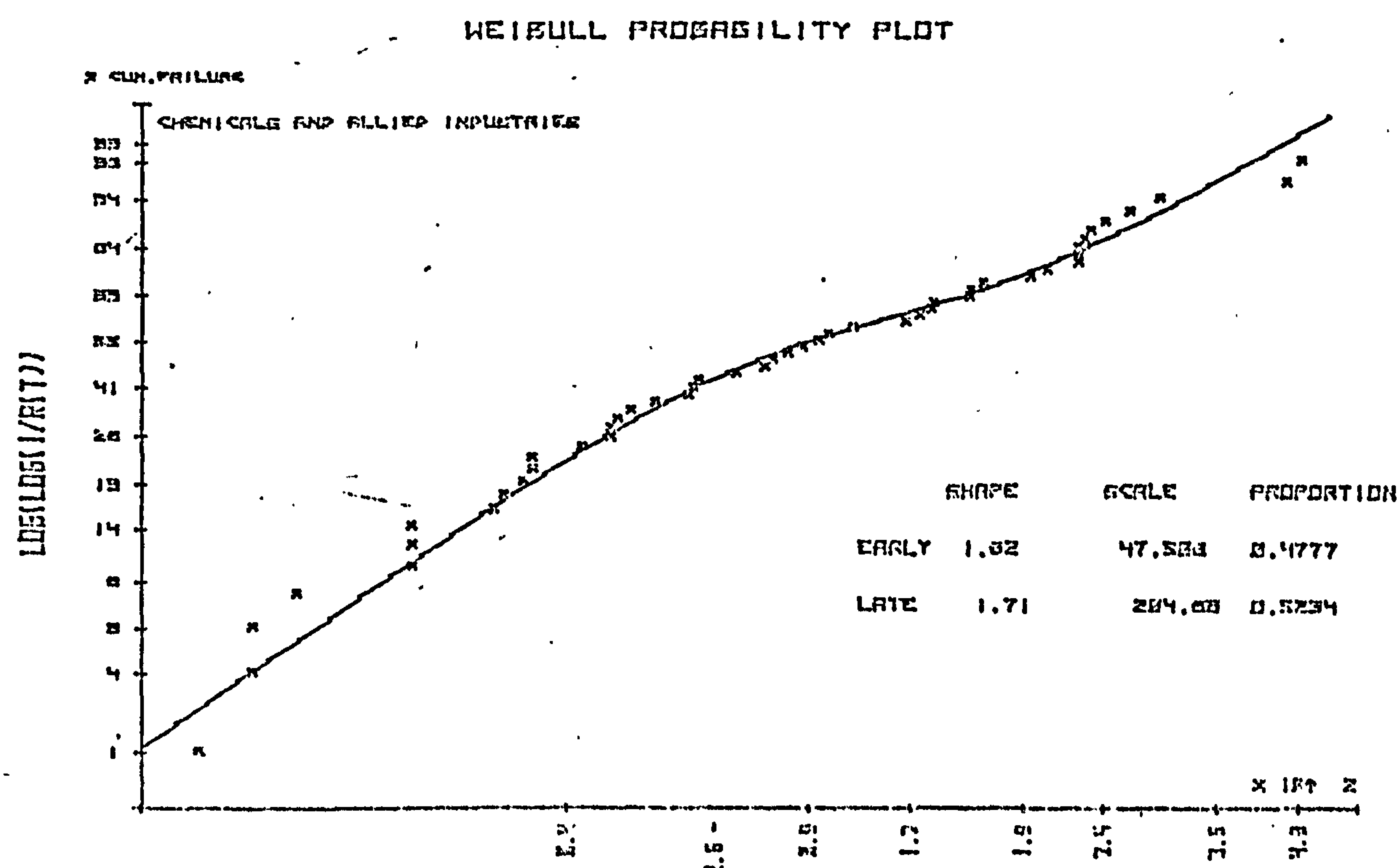

WEIBULL PROBABILITY PLOT
% CUM.FAILURE
CHEMICALS AND ALLIED INDUSTRIES
LOG(LOG(1/R(T)))
SHAPE SCALE PROPORTION
EARLY 1.02 47.583 0.4777
LATE 1.71 284.68 0.5234
X 10↑ 2

Fig. B.6

LOG TIME

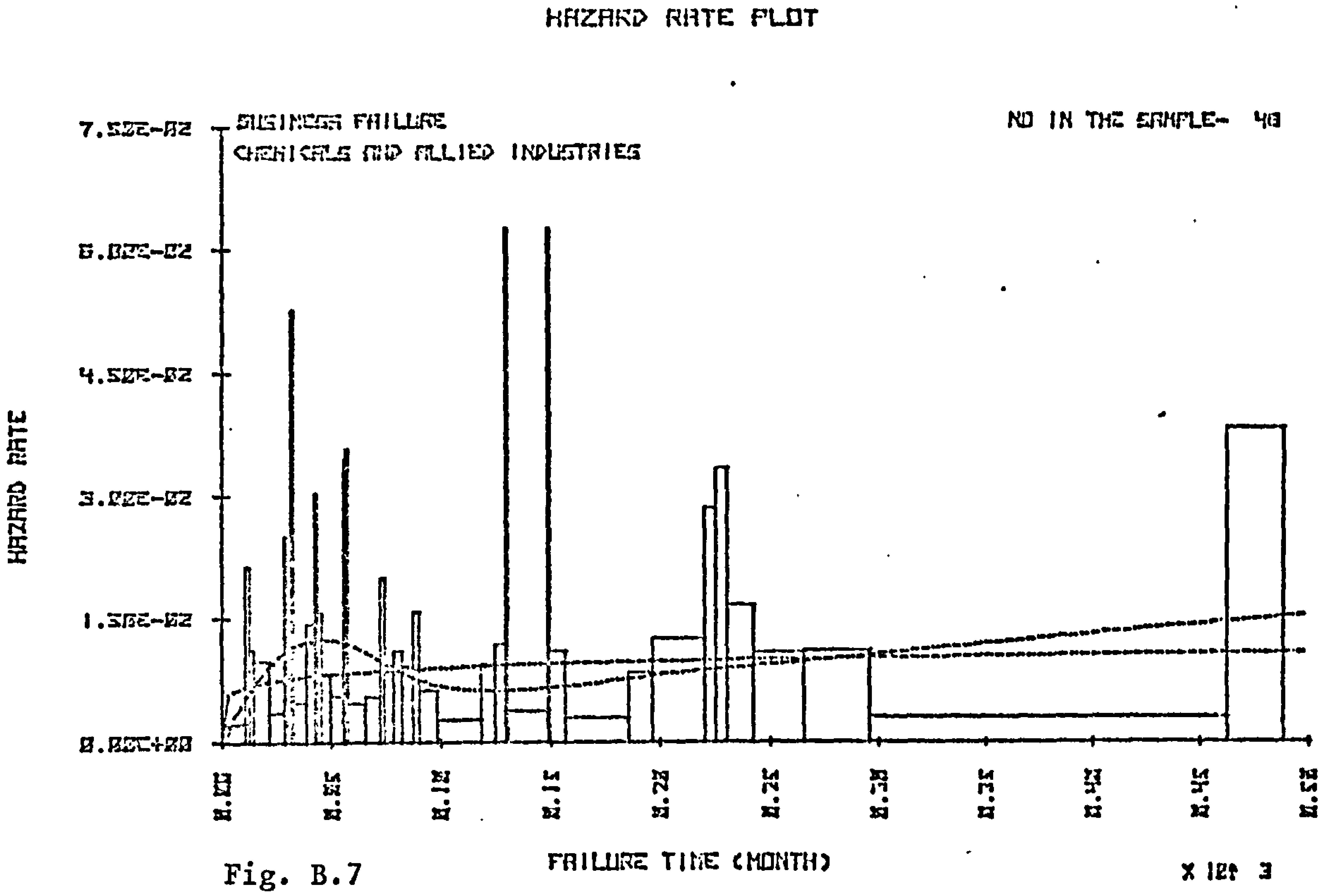

HAZARD RATE PLOT
BUSINESS FAILURE
CHEMICALS AND ALLIED INDUSTRIES
NO IN THE SAMPLE- 40
7.50E-02
6.00E-02
4.50E-02
3.00E-02
1.50E-02
0.00E+00
HAZARD RATE
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
FAILURE TIME (MONTH)
X 10↑ 3

Fig. B.7

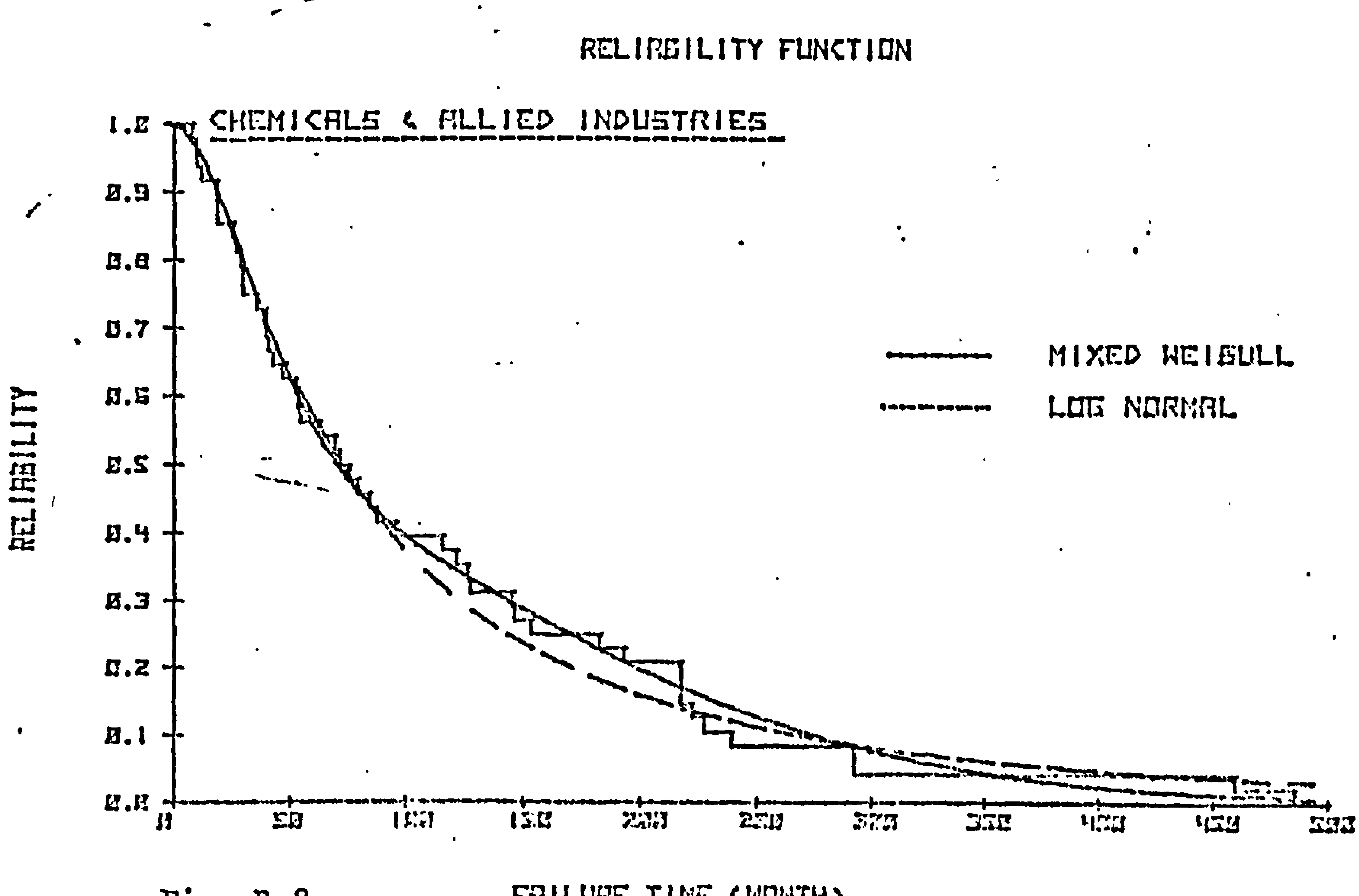

RELIABILITY FUNCTION
CHEMICALS & ALLIED INDUSTRIES
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
RELIABILITY
MIXED WEIBULL
LOG NORMAL
0
50
100
150
200
250
300
350
400
450
500
FAILURE TIME (MONTH)

Fig. B.8

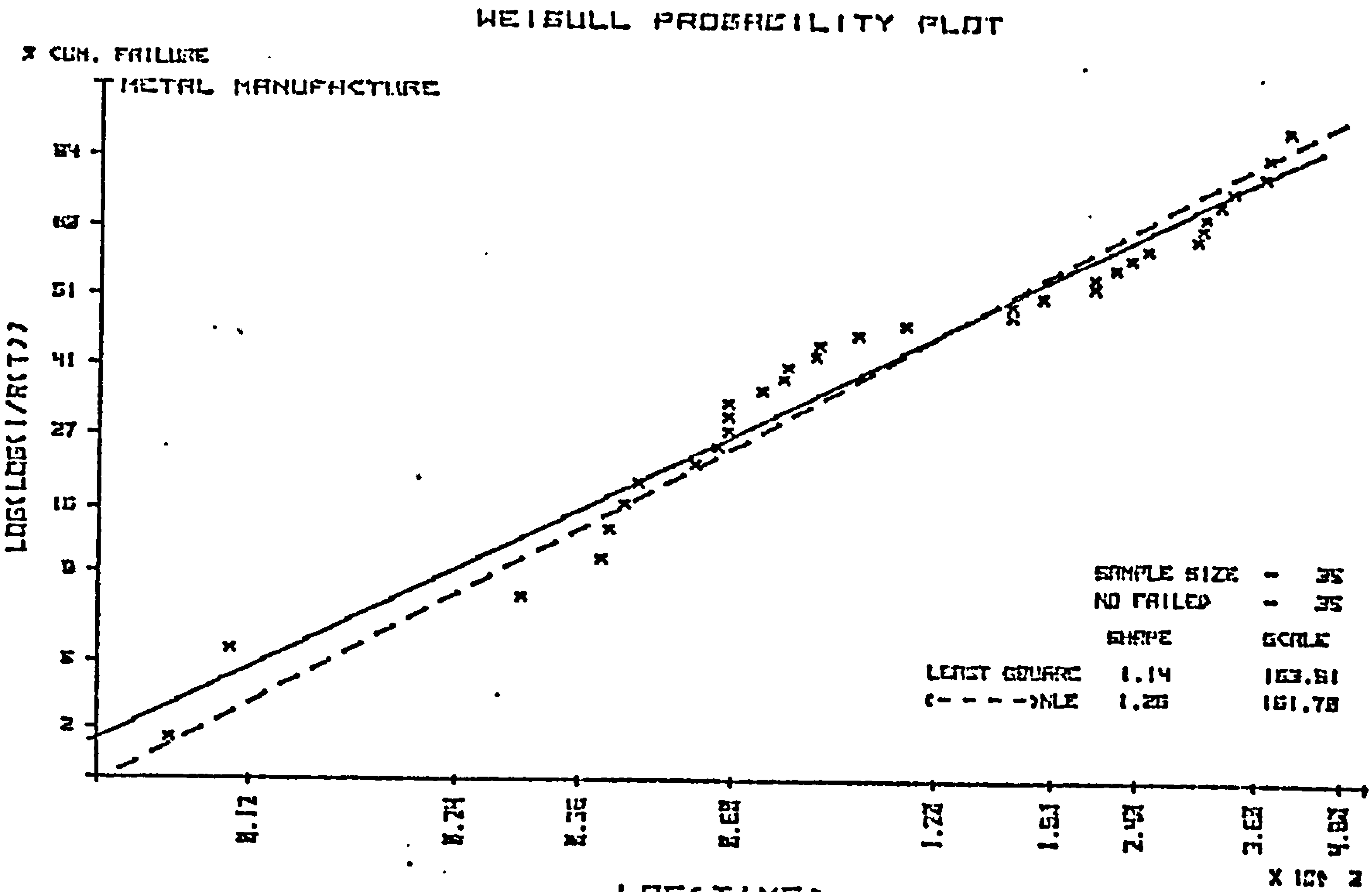


Fig. B.9

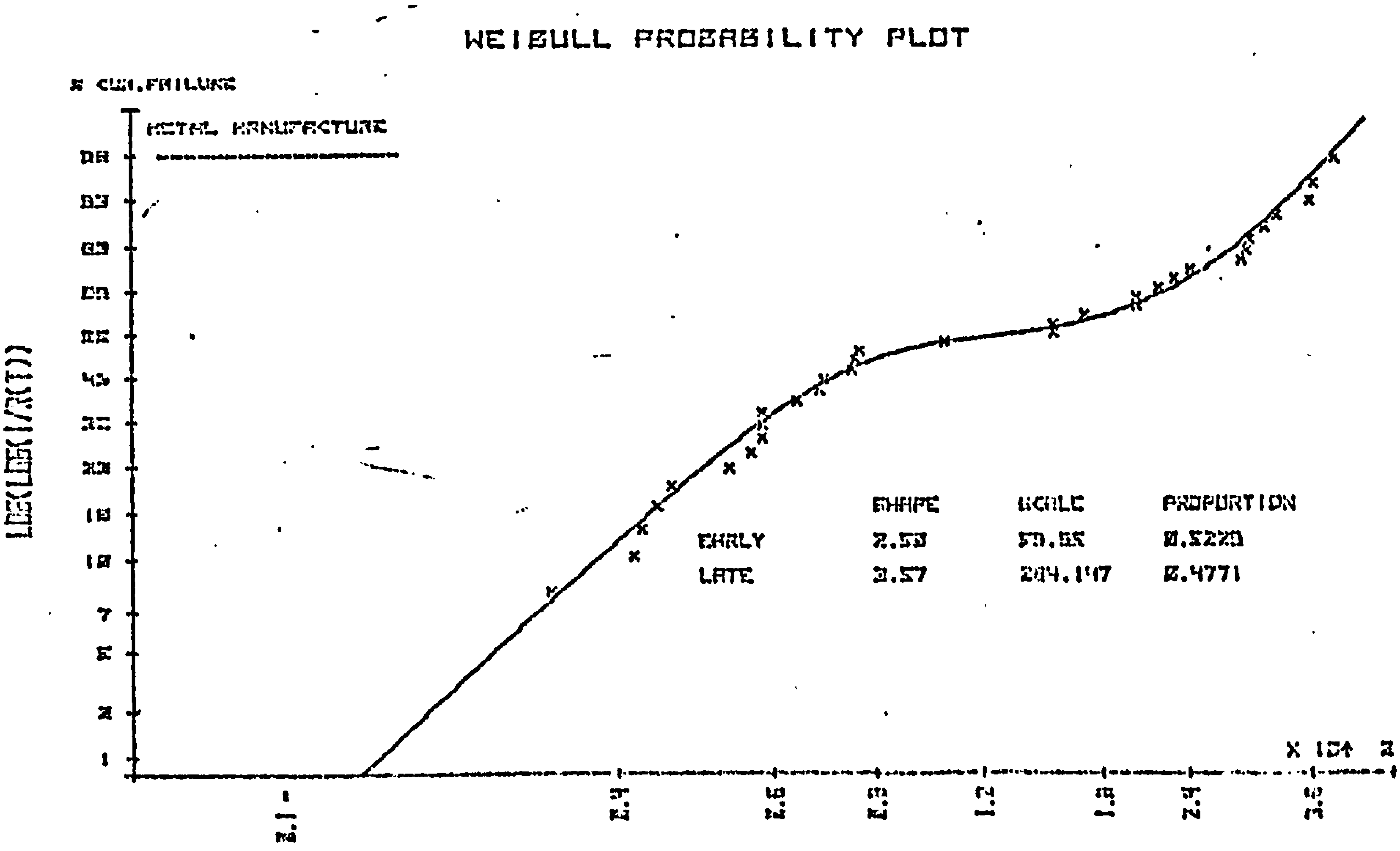


Fig. B.10

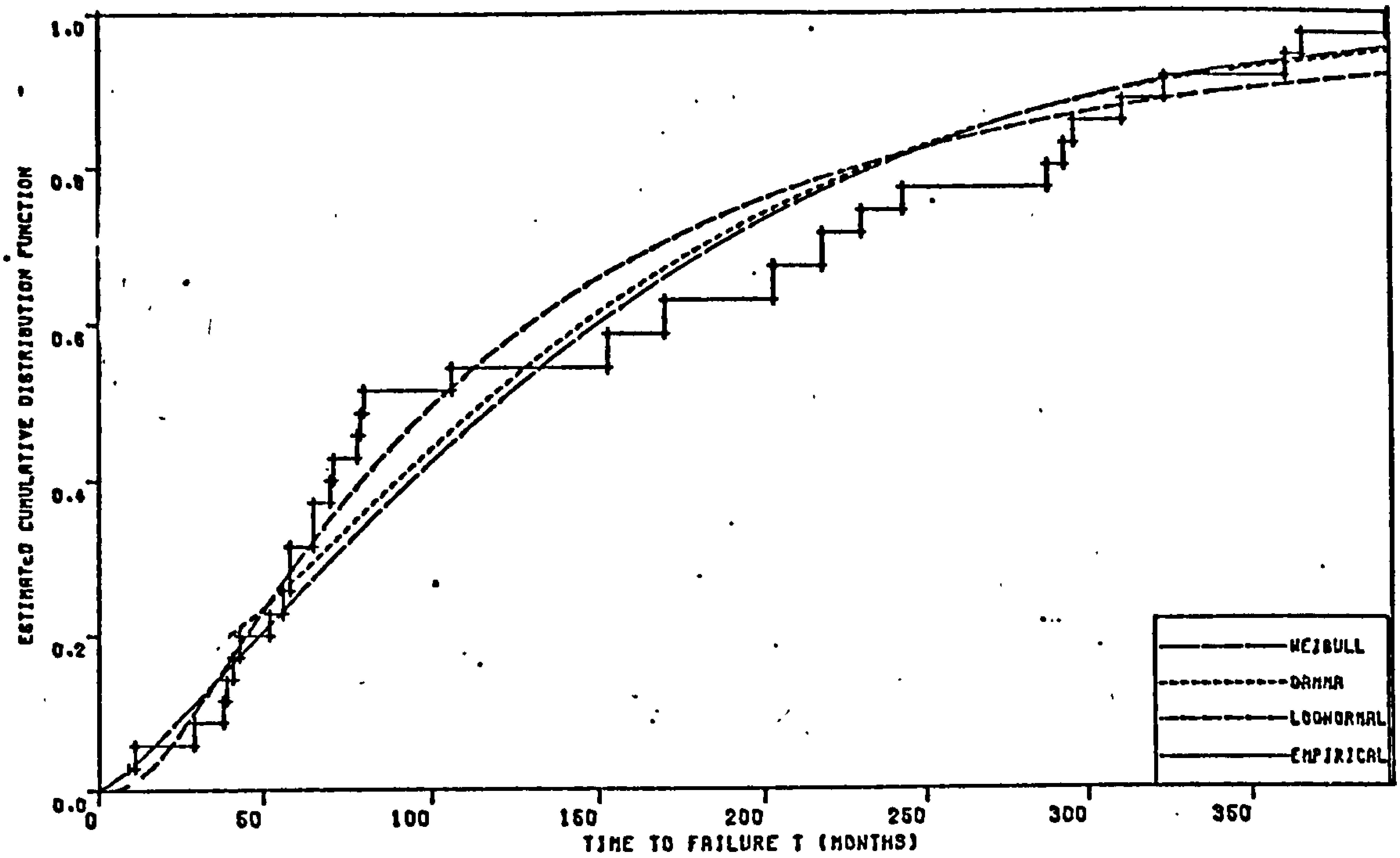


Fig. B.11 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

<u>METAL MANUFACTURE</u>

	SHAPE	SCALE
LOG-NORMAL	0.97	4.62
WEIBULL	1.26	169
GAMMA	1.61	93

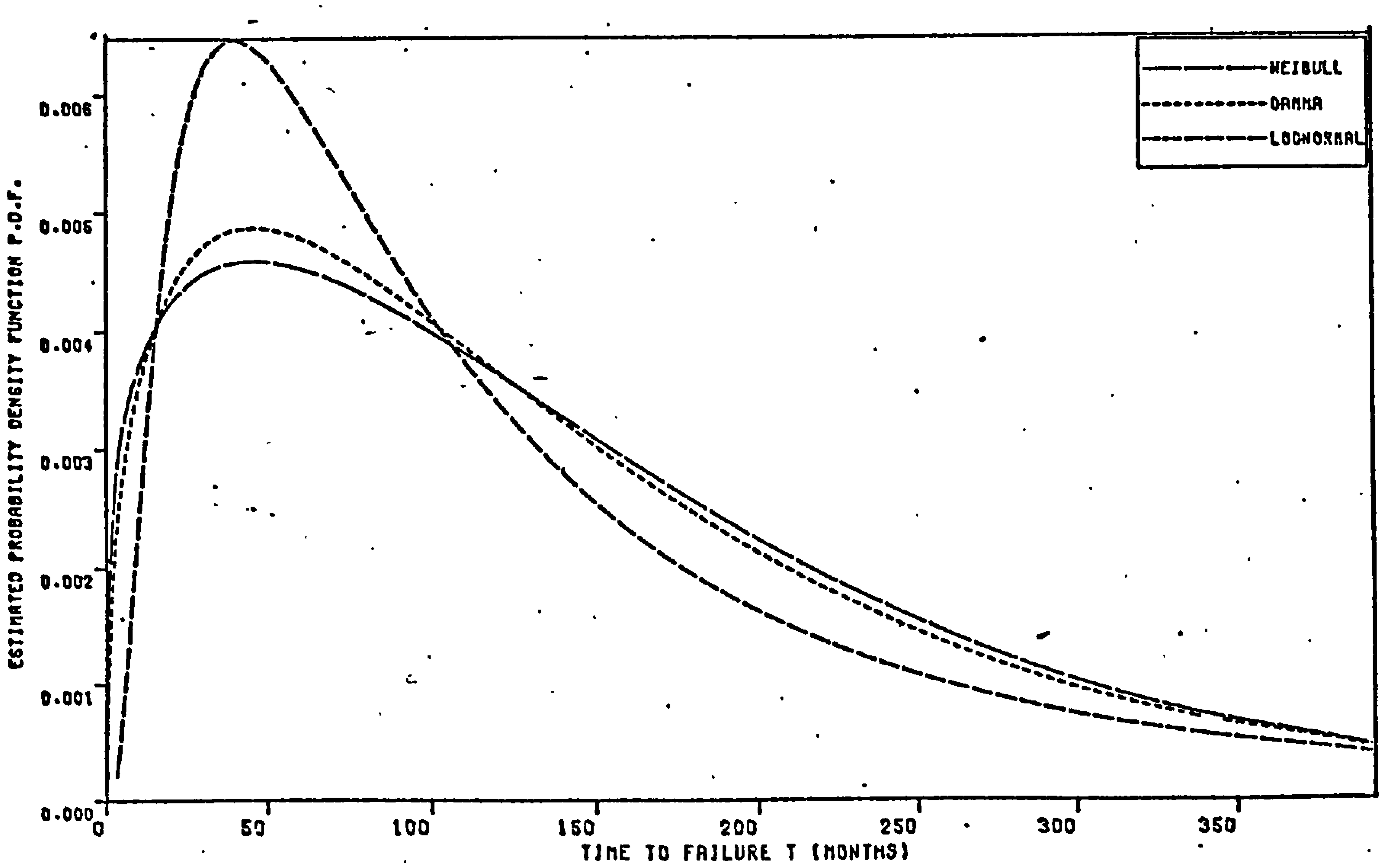


Fig. B.12 FIG : PROBABILITY DENSITY FUNCTIONS.
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

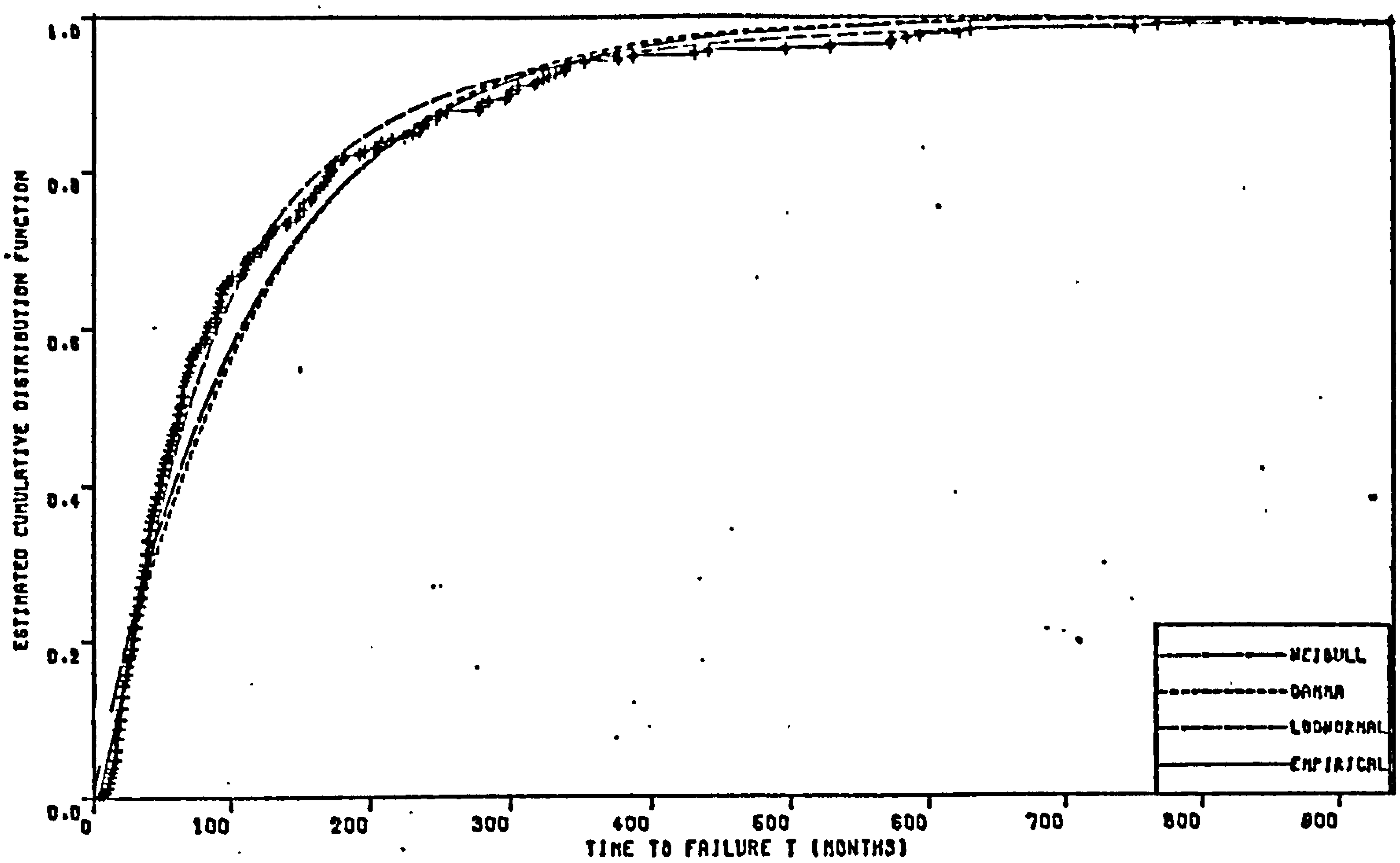


Fig. B.13 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MECHANICAL ENGINEERING

	SHAPE	SCALE
LOG-NORMAL	1.03	4.24
WEIBULL	0.96	117
GAMMA	0.66	181

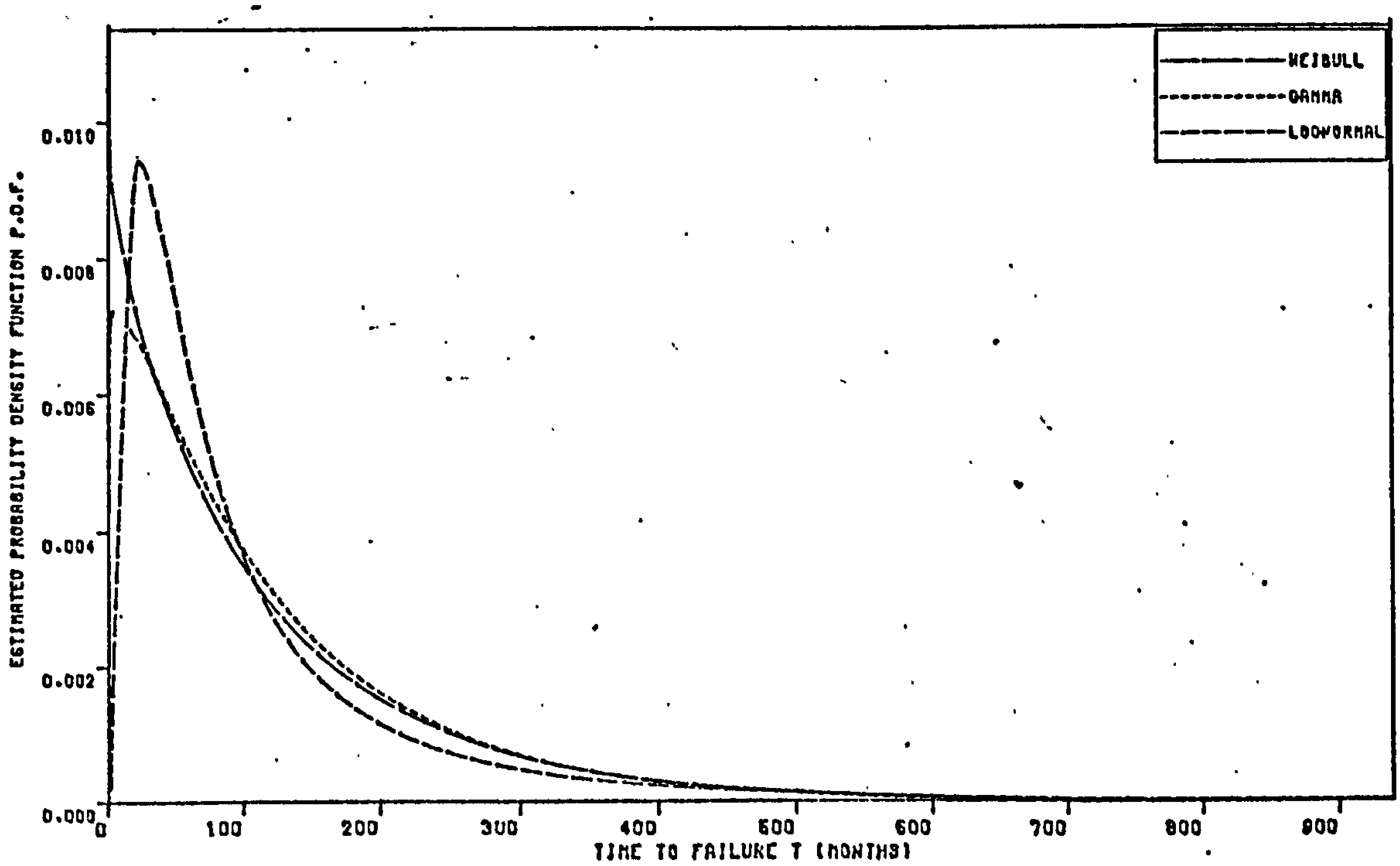


Fig. B.14 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

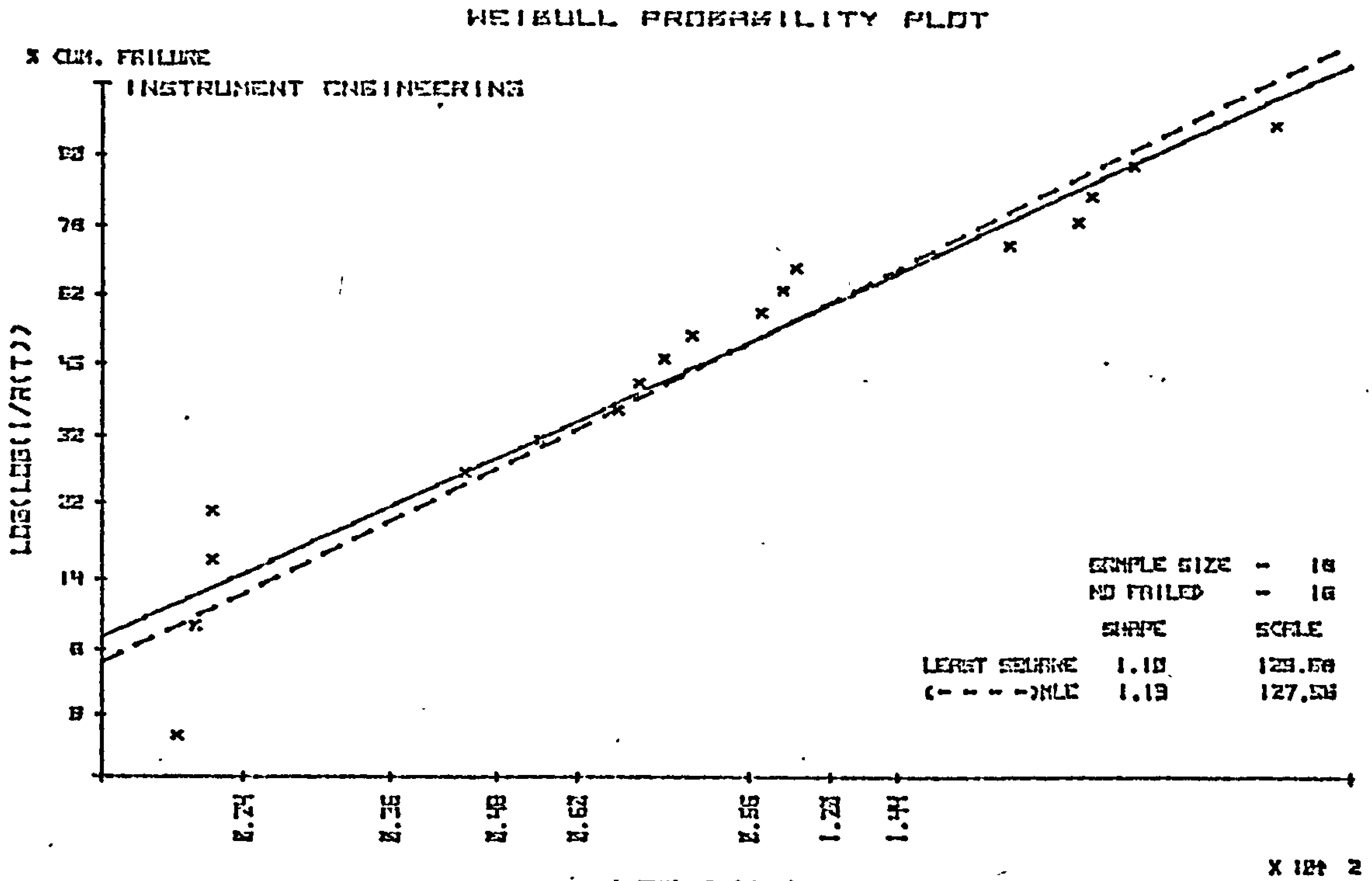


Fig. B.15

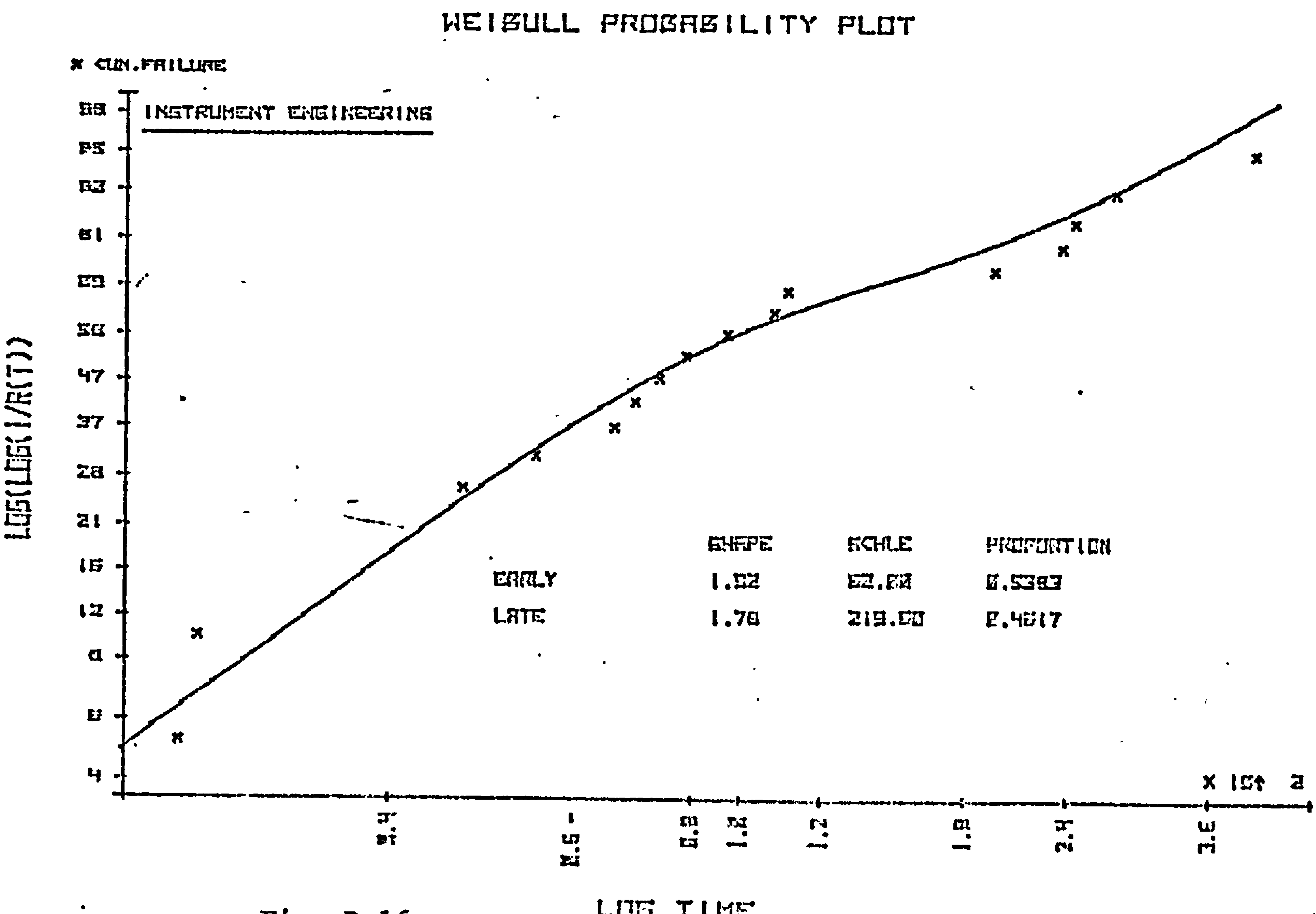


Fig. B.16

HAZARD RATE PLOT

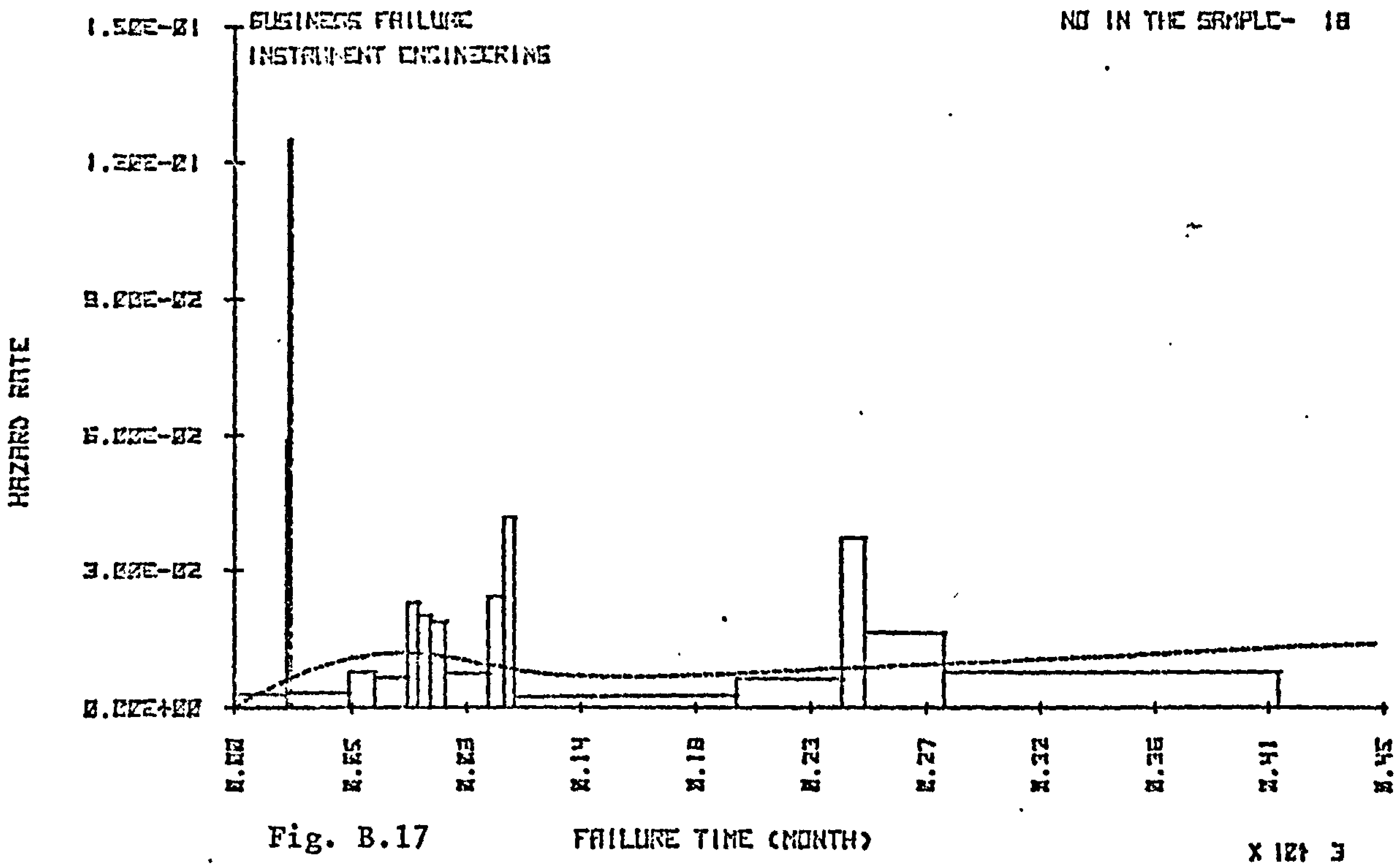


Fig. B.17

RELIABILITY FUNCTION

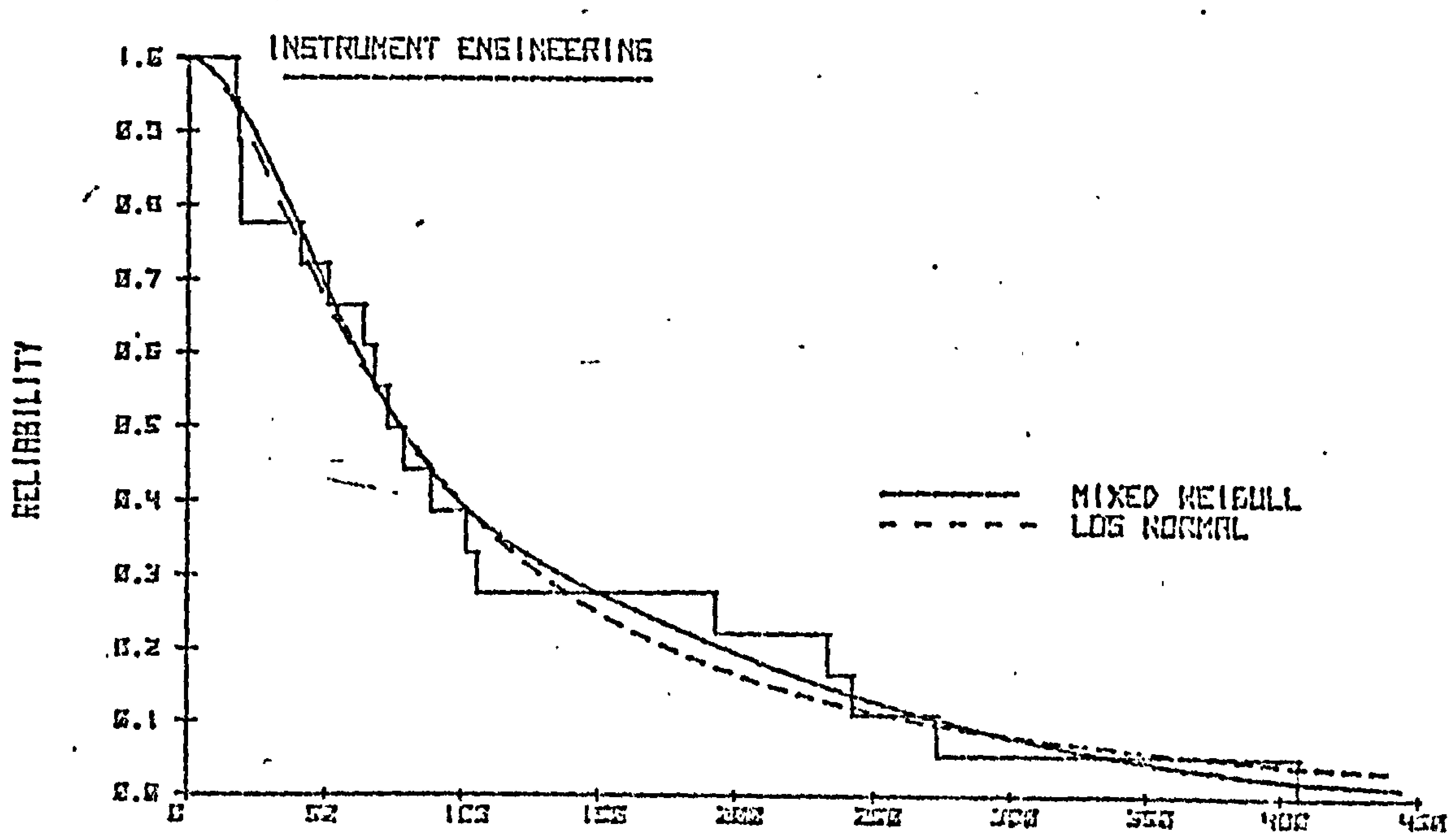


Fig. B.18

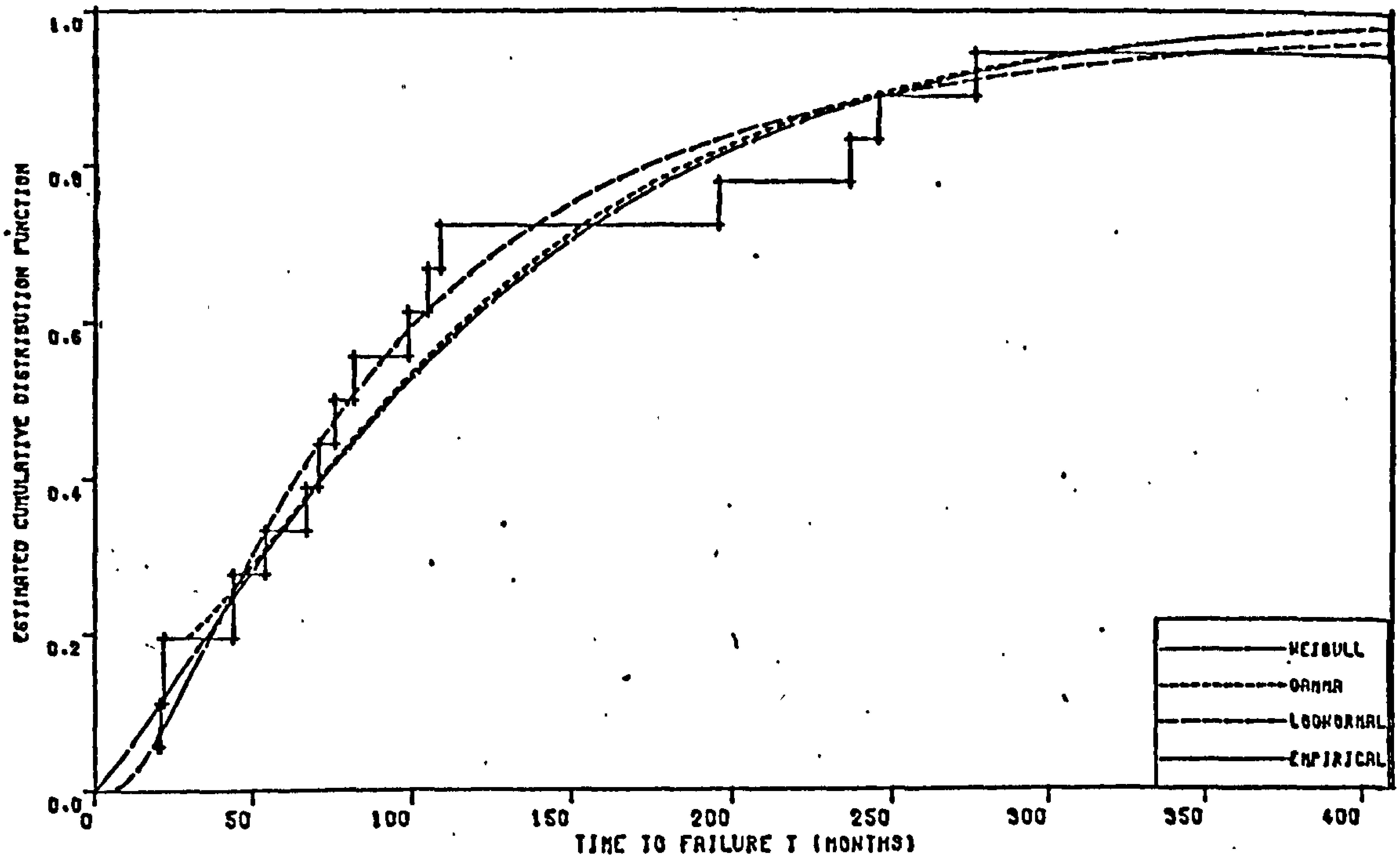


Fig. B.19

FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS
INSTRUMENT ENGINEERING

	SHAPE	SCALE
LOG-NORMAL	0.92	4.39
WEIBULL	1.18	128
GAMMA	1.21	99

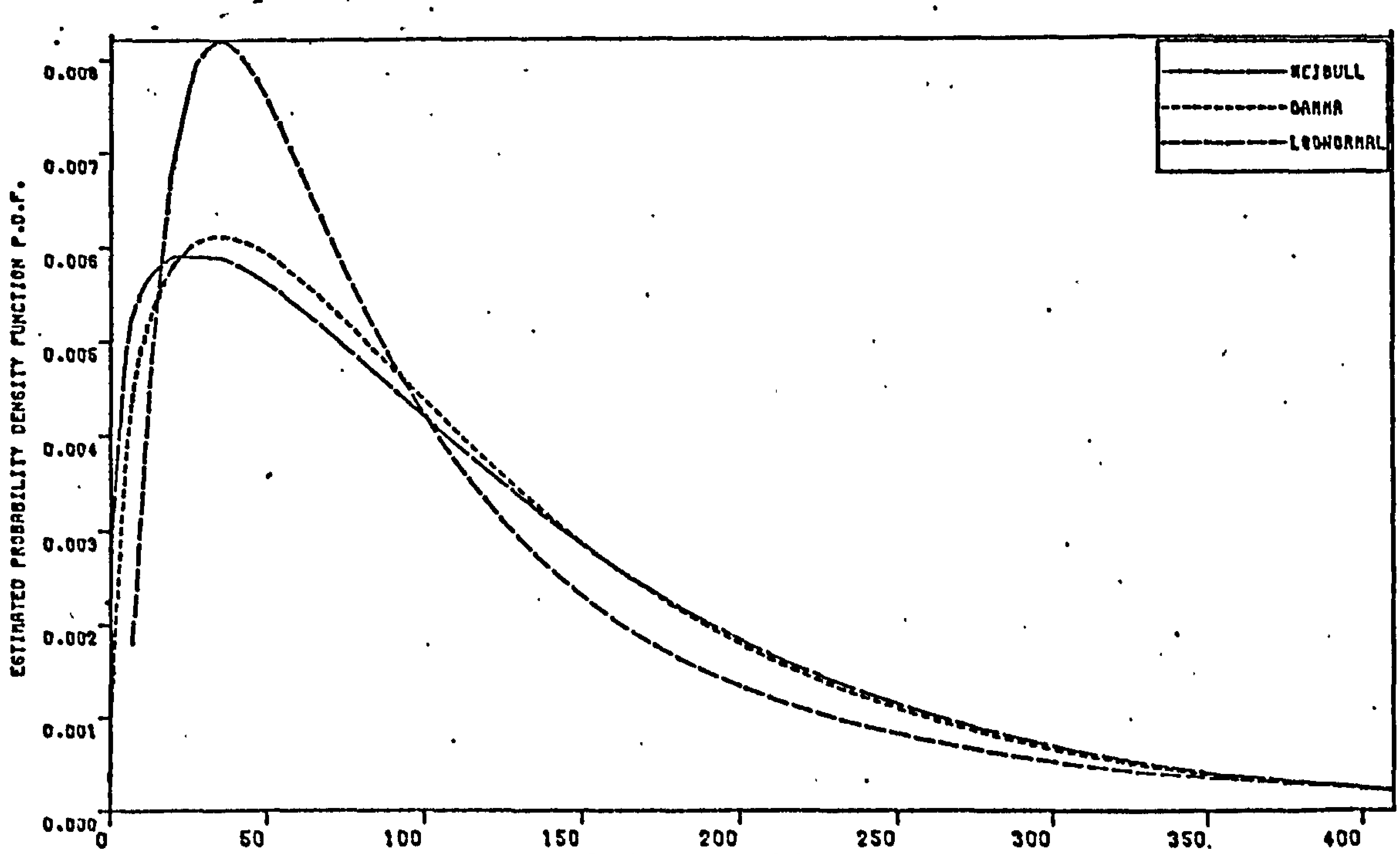


Fig. B.20

FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

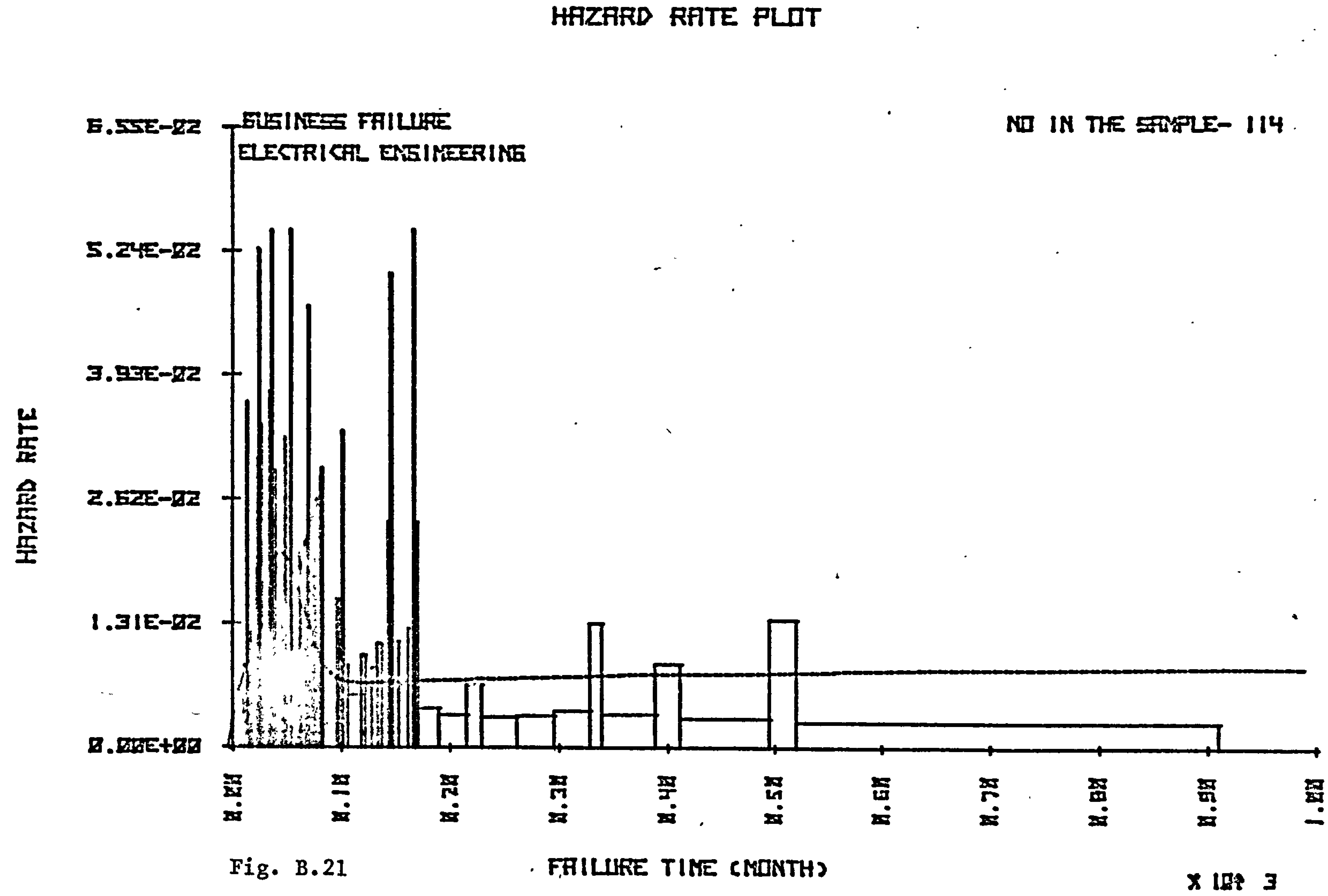

HAZARD RATE PLOT
BUSINESS FAILURE
ELECTRICAL ENGINEERING
NO IN THE SAMPLE- 114
HAZARD RATE
6.55E-02
5.24E-02
3.93E-02
2.62E-02
1.31E-02
0.00E+00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
FAILURE TIME (MONTH)
X 10↑ 3

Fig. B.21

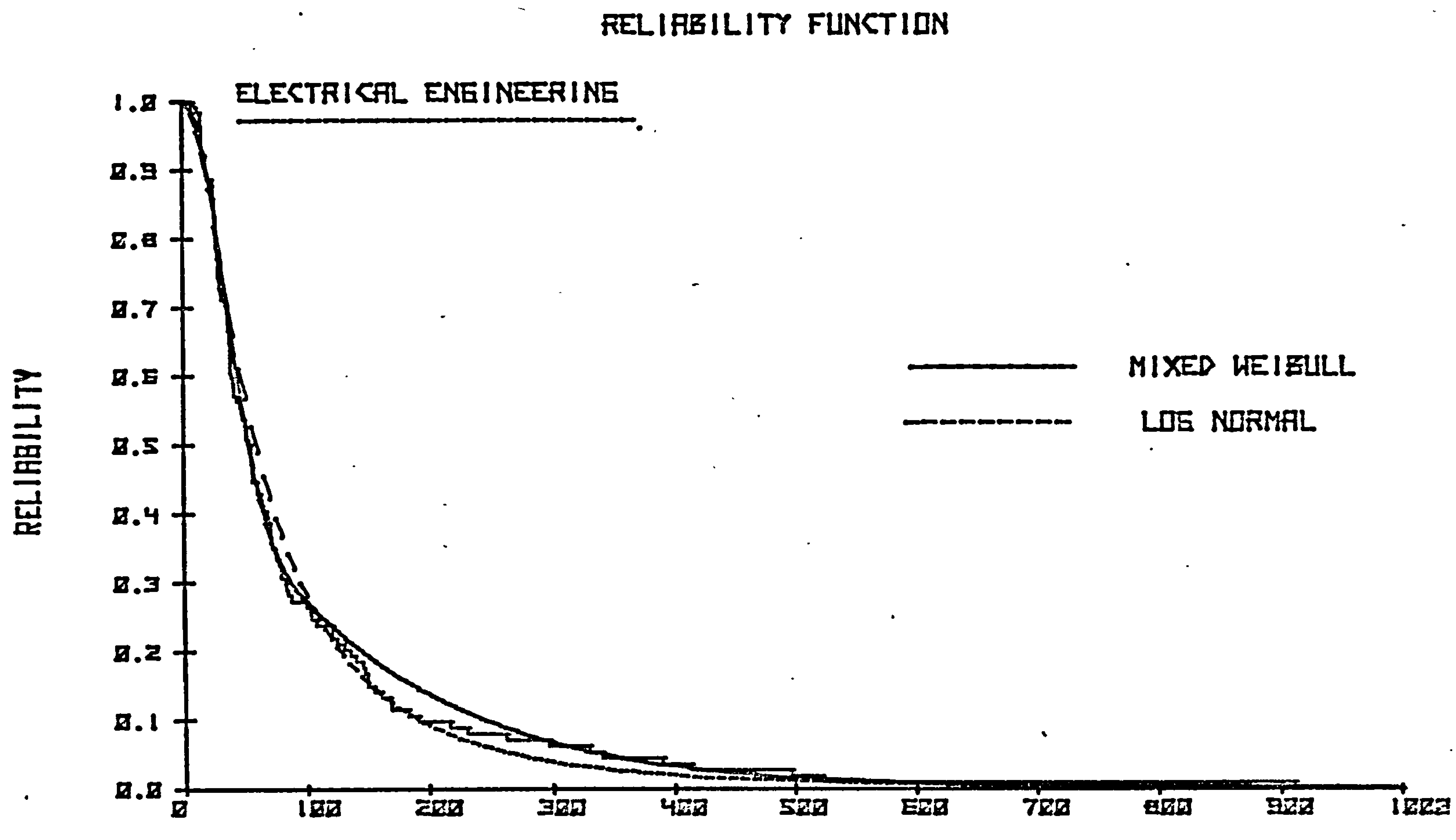

RELIABILITY FUNCTION
ELECTRICAL ENGINEERING
MIXED WEIBULL
LOG NORMAL
RELIABILITY
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
100
200
300
400
500
600
700
800
900
1000
FAILUR TIME (MONTH)

Fig. B.22

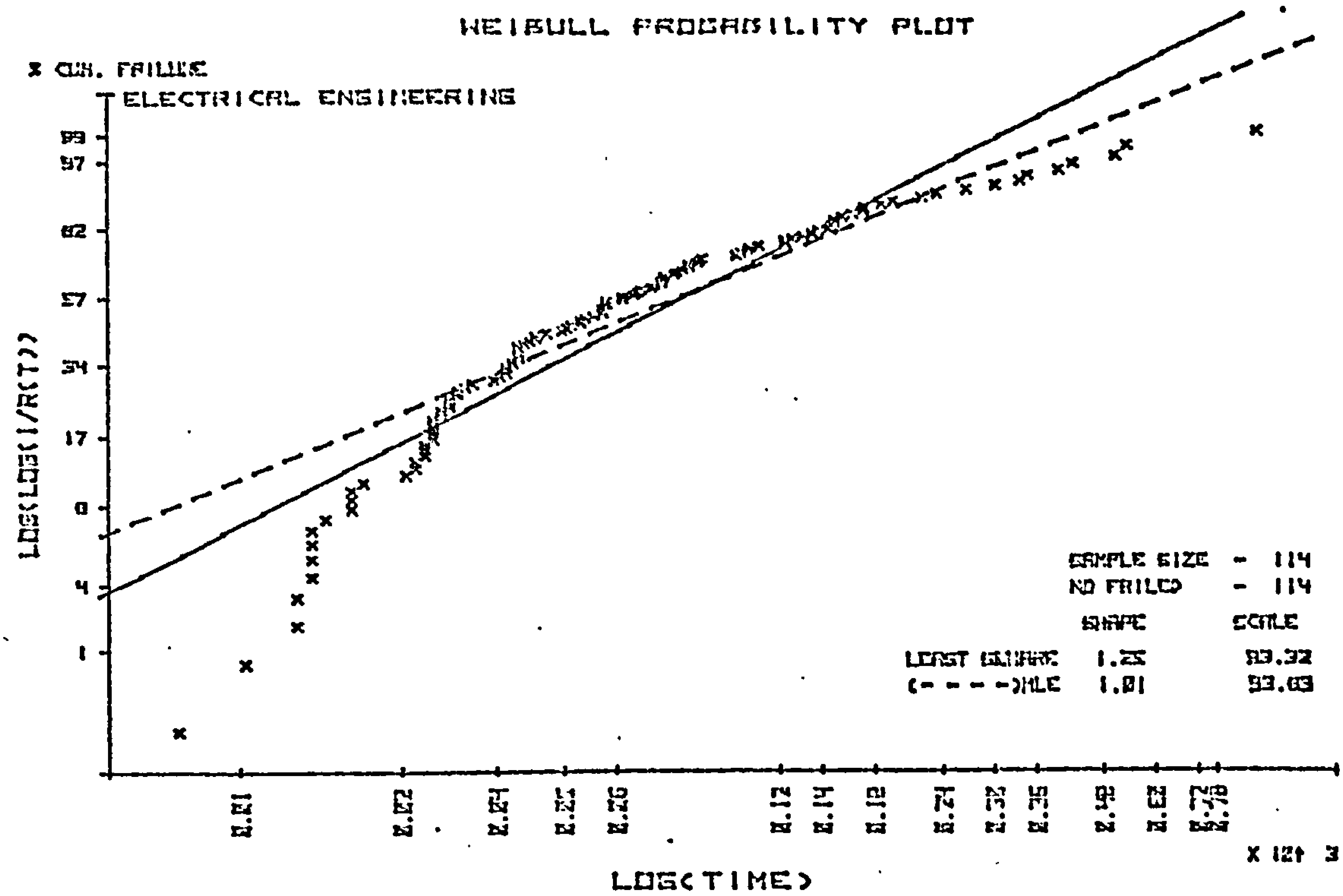


Fig. B.23

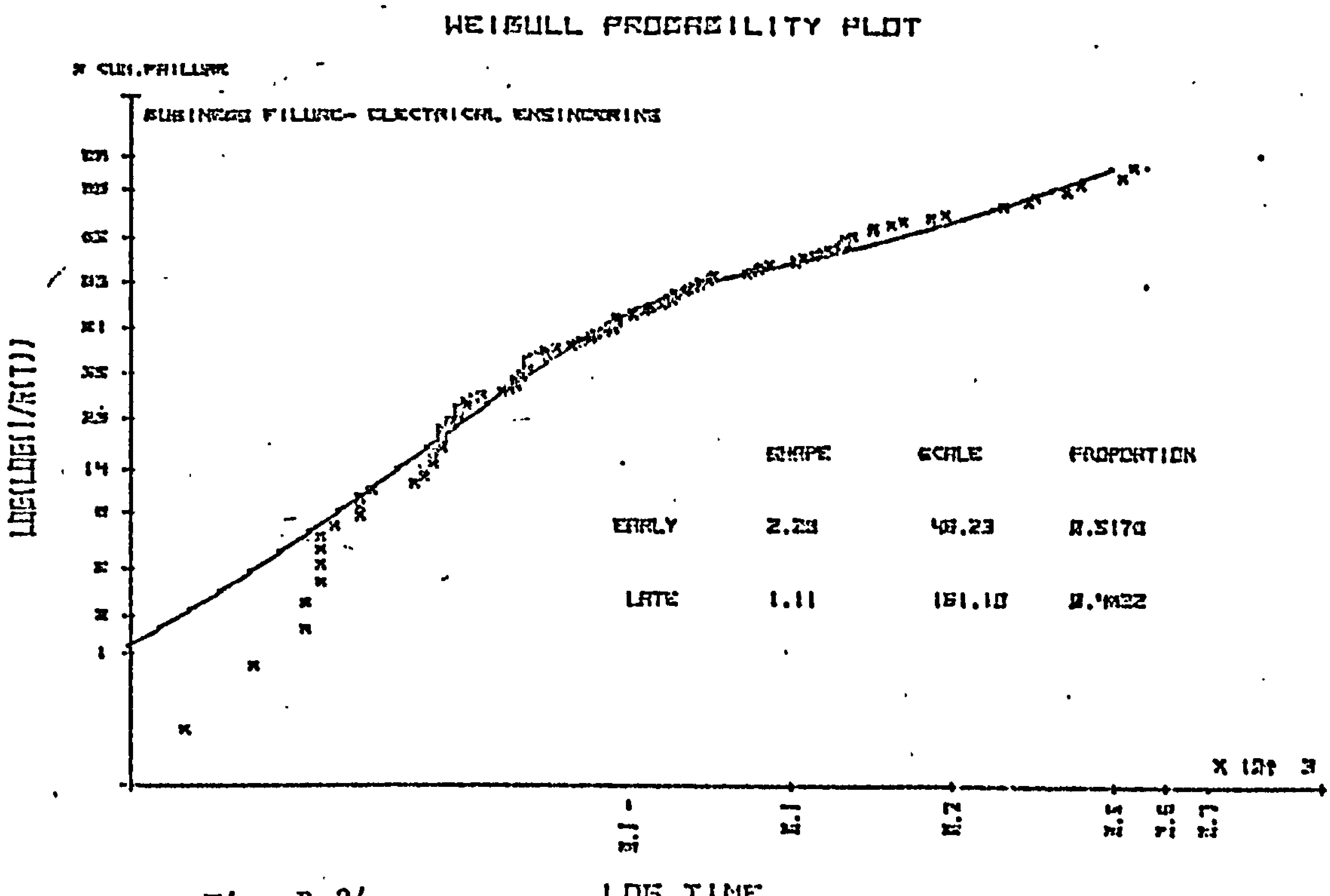


Fig. B.24

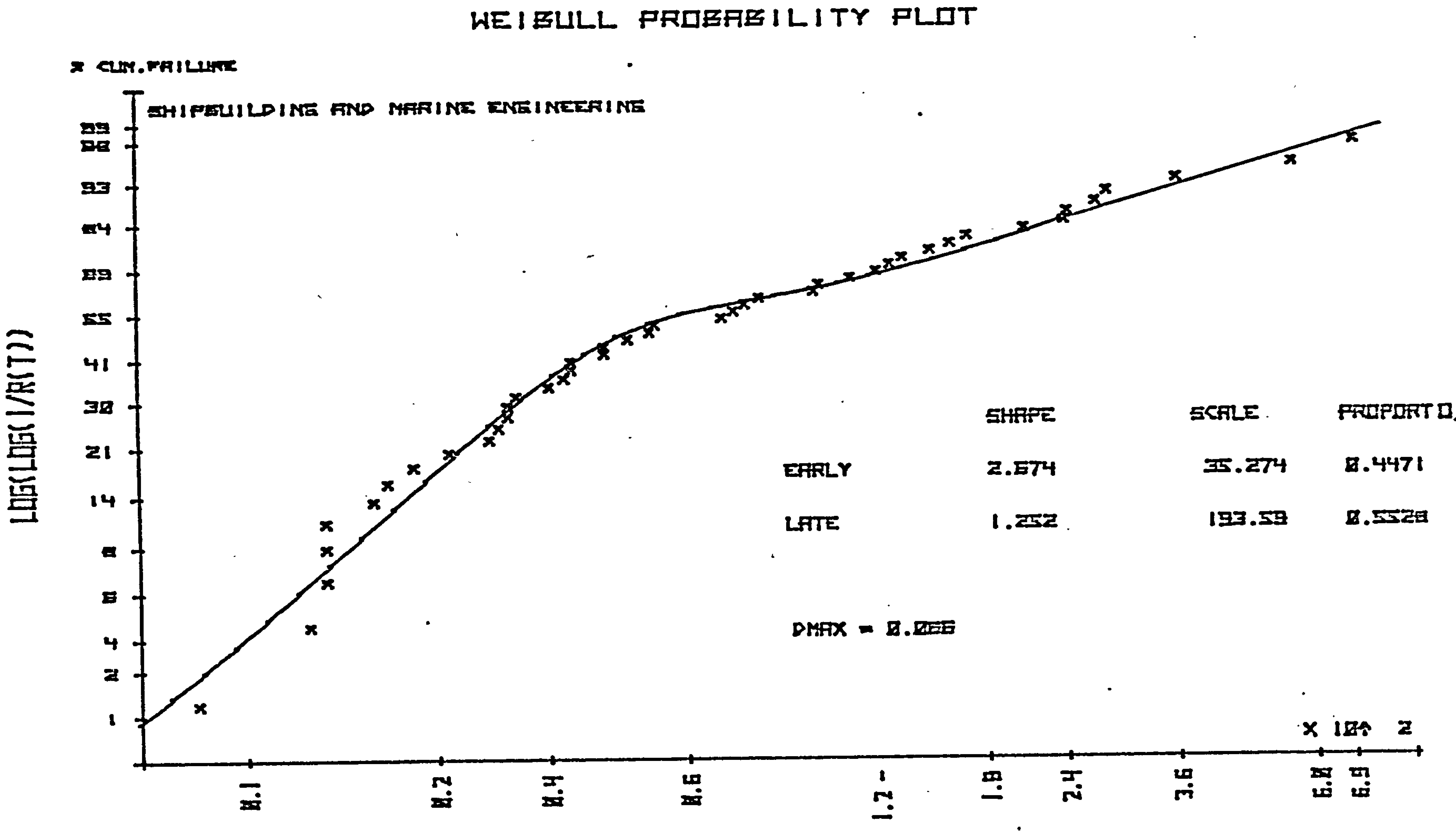

WEIBULL PROBABILITY PLOT
% CUM.FAILURE
SHIPBUILDING AND MARINE ENGINEERING
99
98
93
84
69
55
41
30
21
14
10
8
4
2
1
LOG(LOG(1/R(T))
SHAPE
SCALE
PROPORTO.
EARLY
2.674
35.274
0.4471
LATE
1.252
193.59
0.5528
DMAX = 0.066
X 10^ 2
0.1
0.2
0.4
0.6
1.2
1.8
2.4
3.6
6.0
6.9
LOG TIME

Fig. B.25

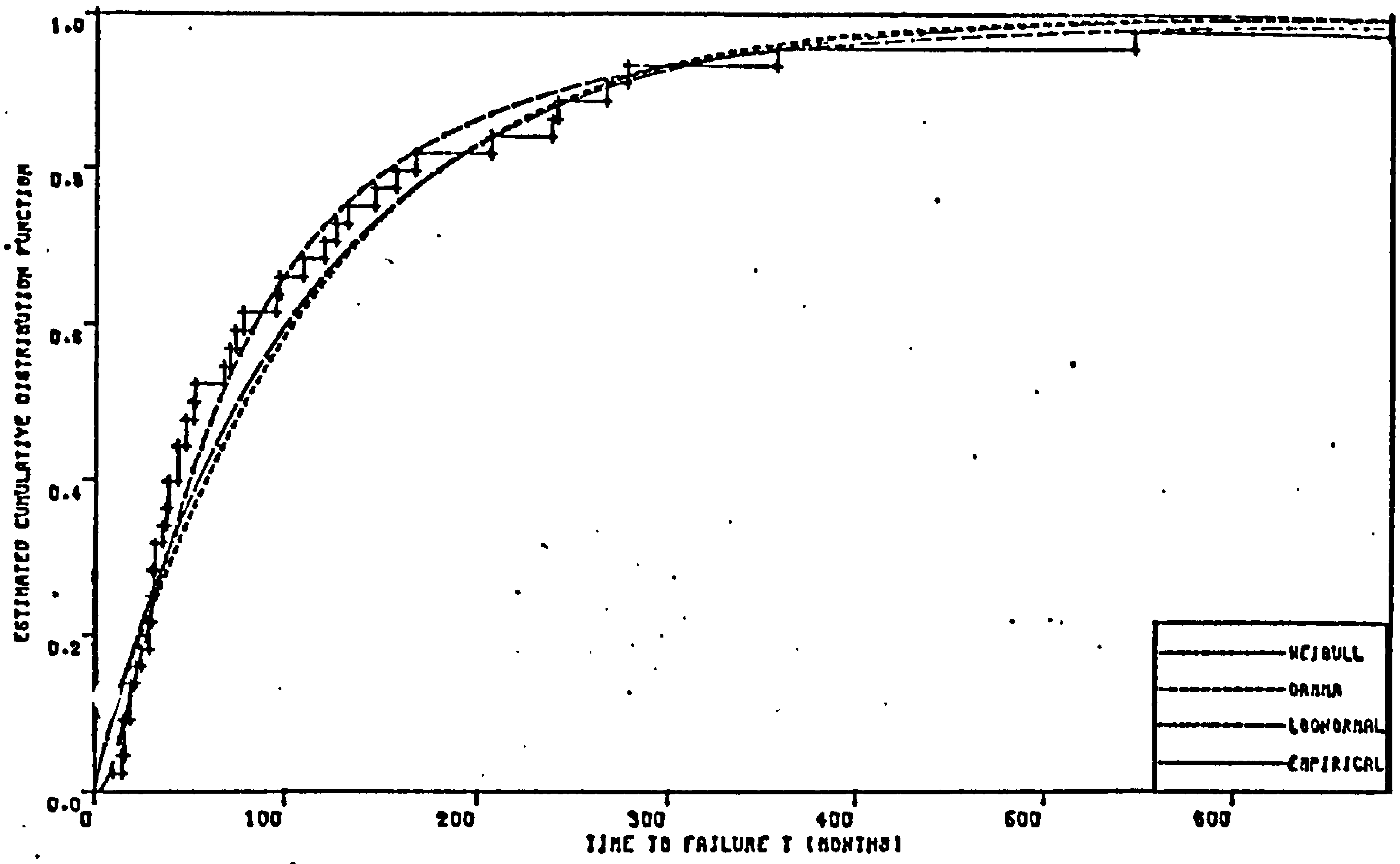


Fig. B.26 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

SHIPBUILDING AND MARINE ENGINEERING

	SHAPE	SCALE
LOG-NORMAL	1.06	4.19
WEIBULL	0.96	111
GAMMA	0.65	172

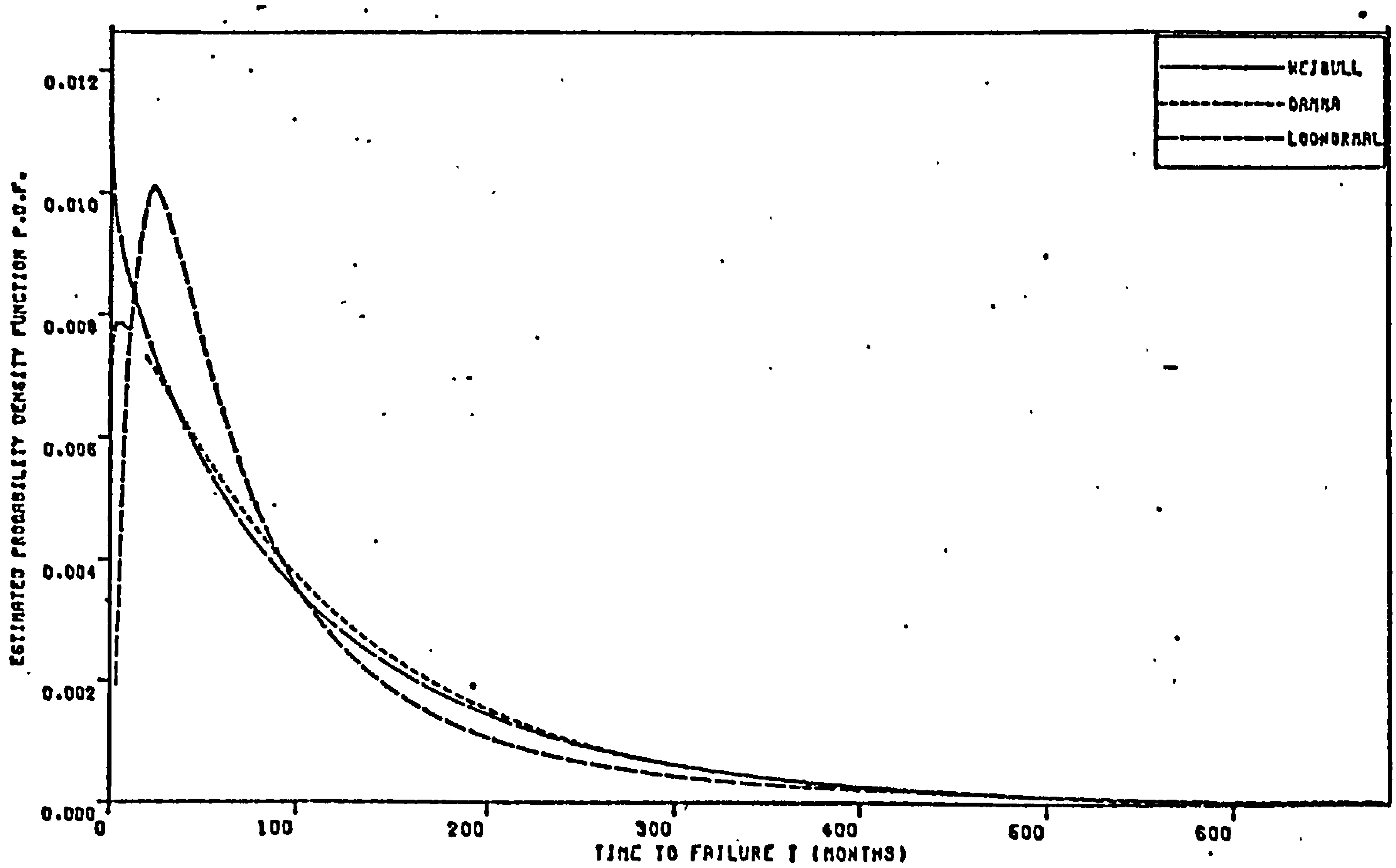


Fig. B.27 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

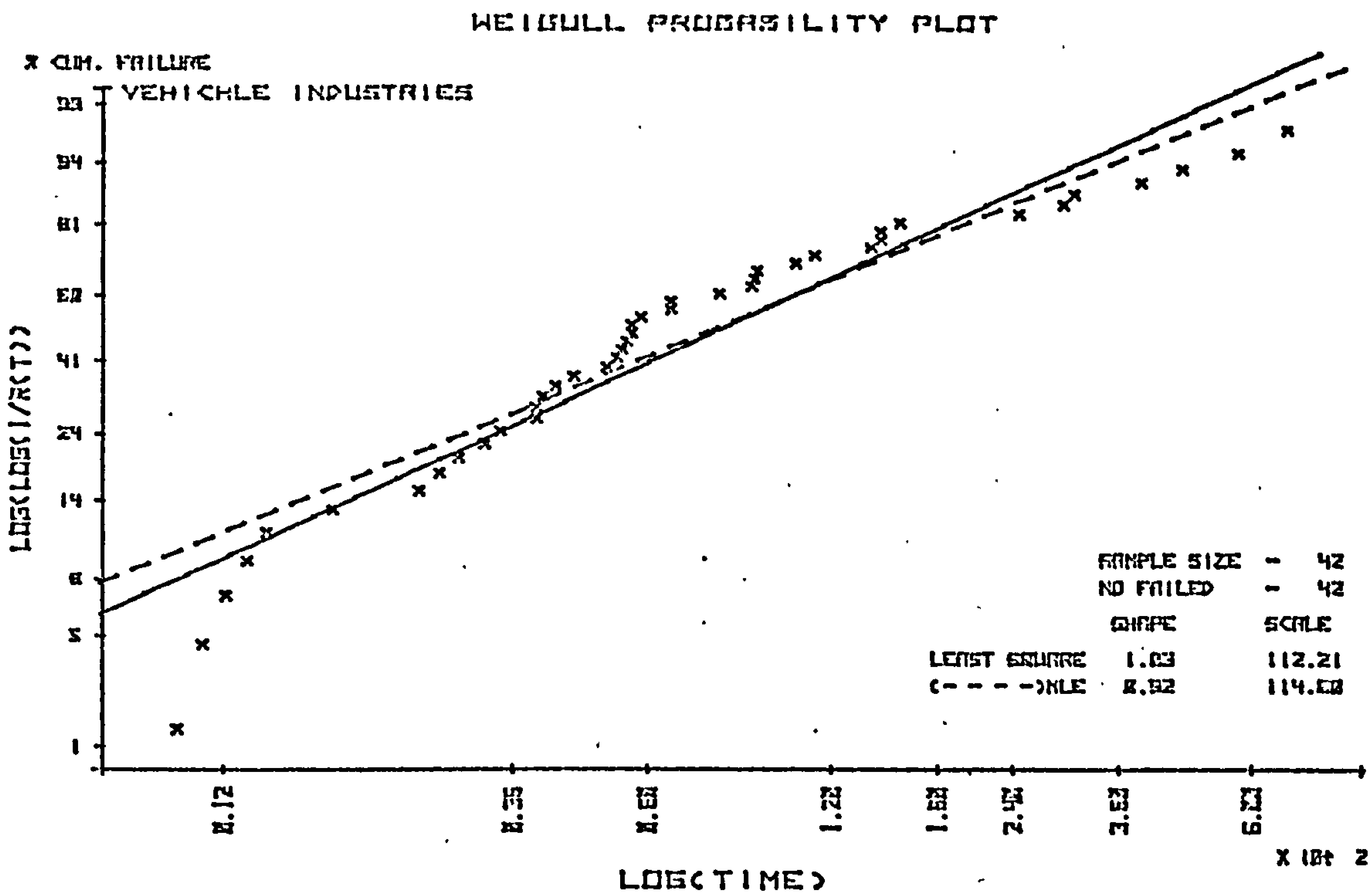


Fig. B.28

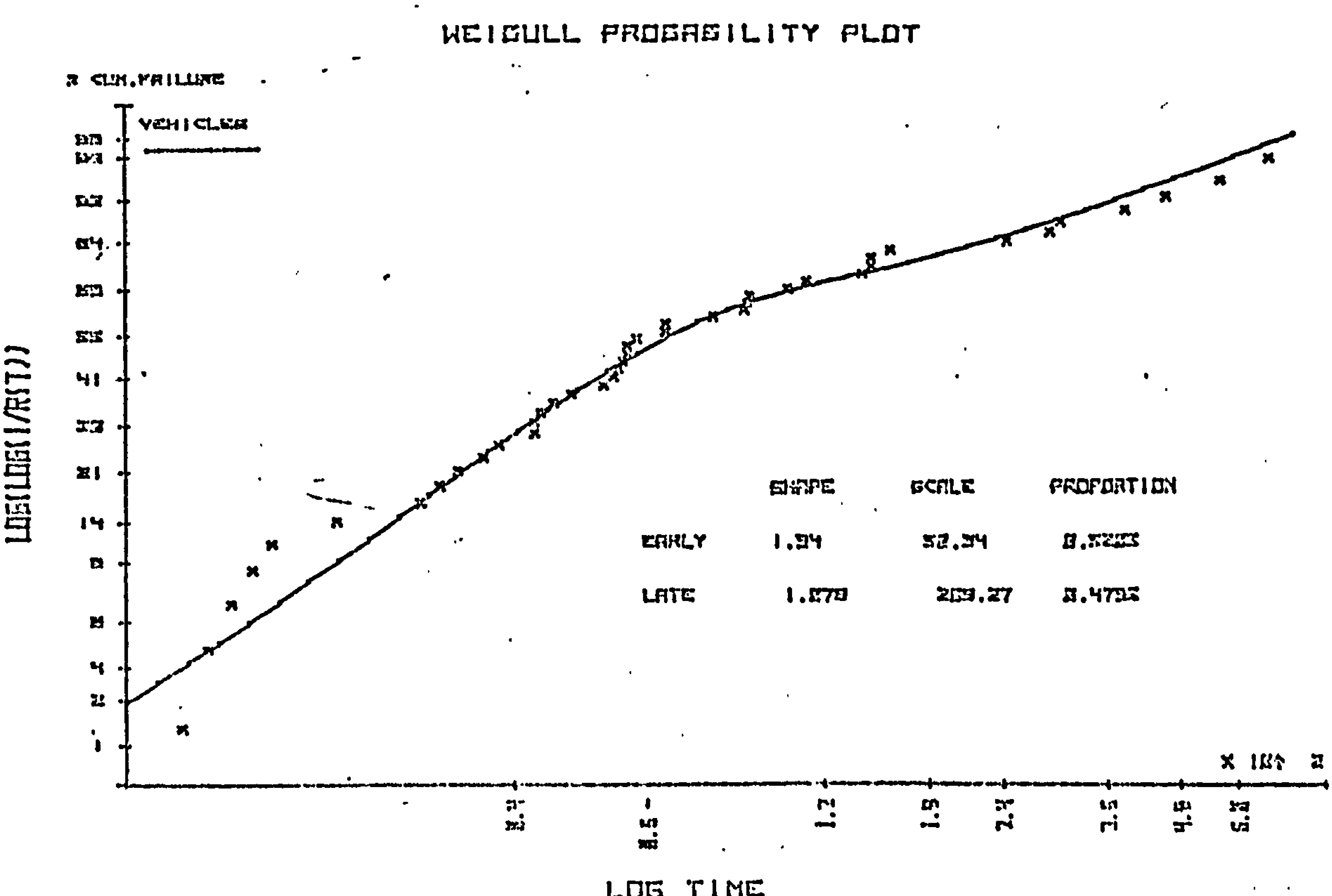


Fig. B.29

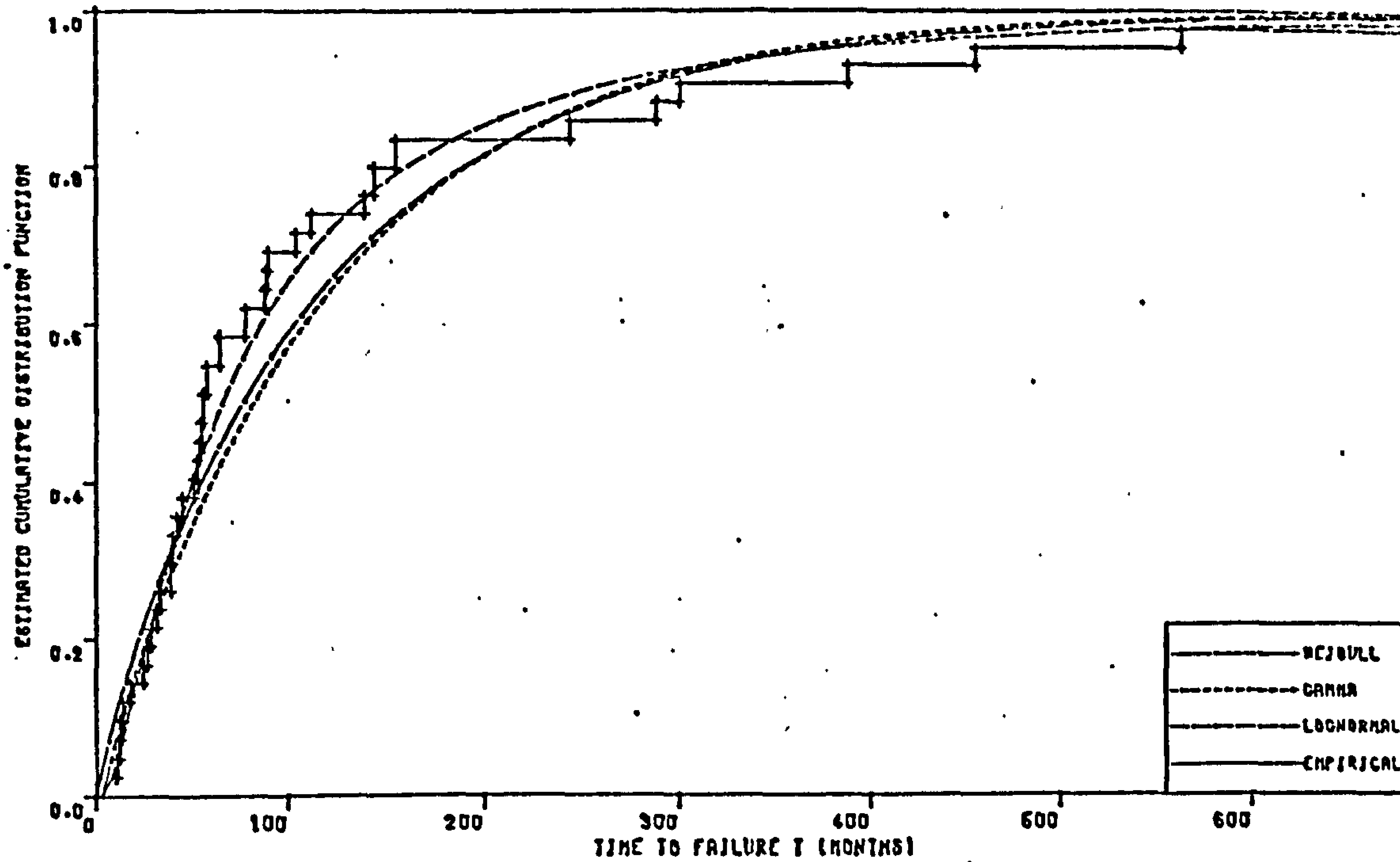


Fig. B.30 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

VEHICLES

	SHAPE	SCALE
LOG-NORMAL	1.06	4.19
WEIBULL	0.92	114
GAMMA	0.61	196

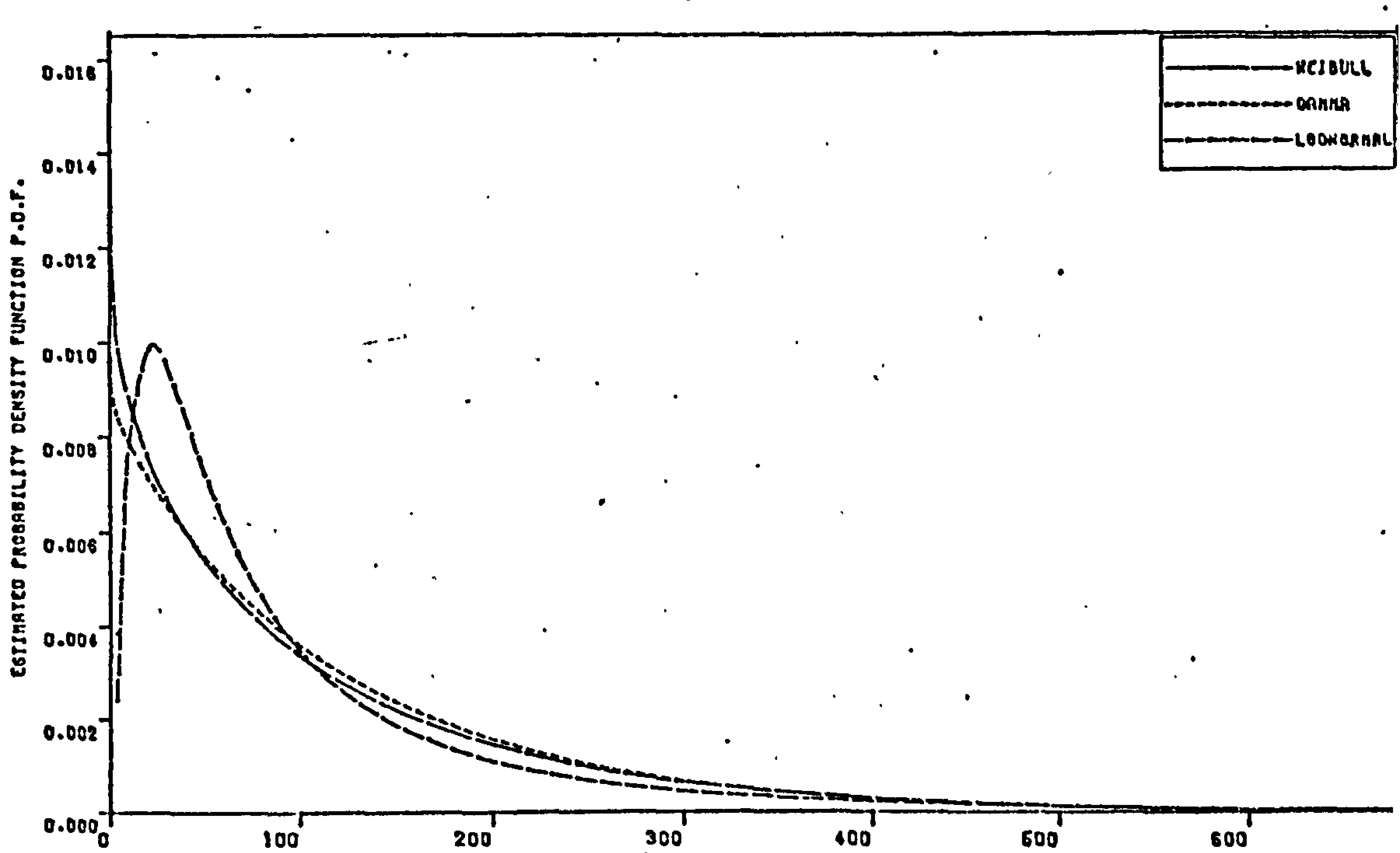


Fig. B.31 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

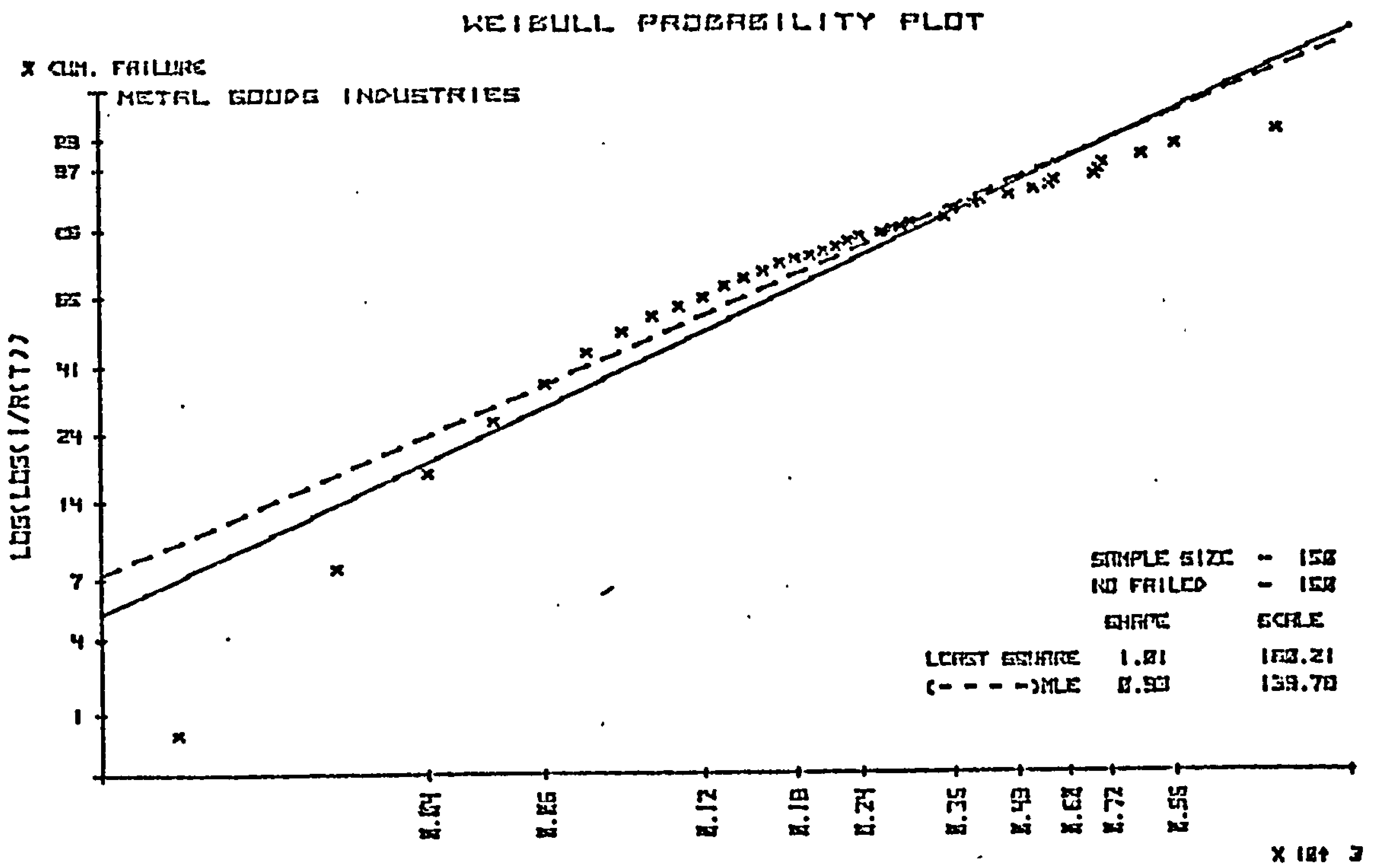


Fig. B.32 LOG(TIME)

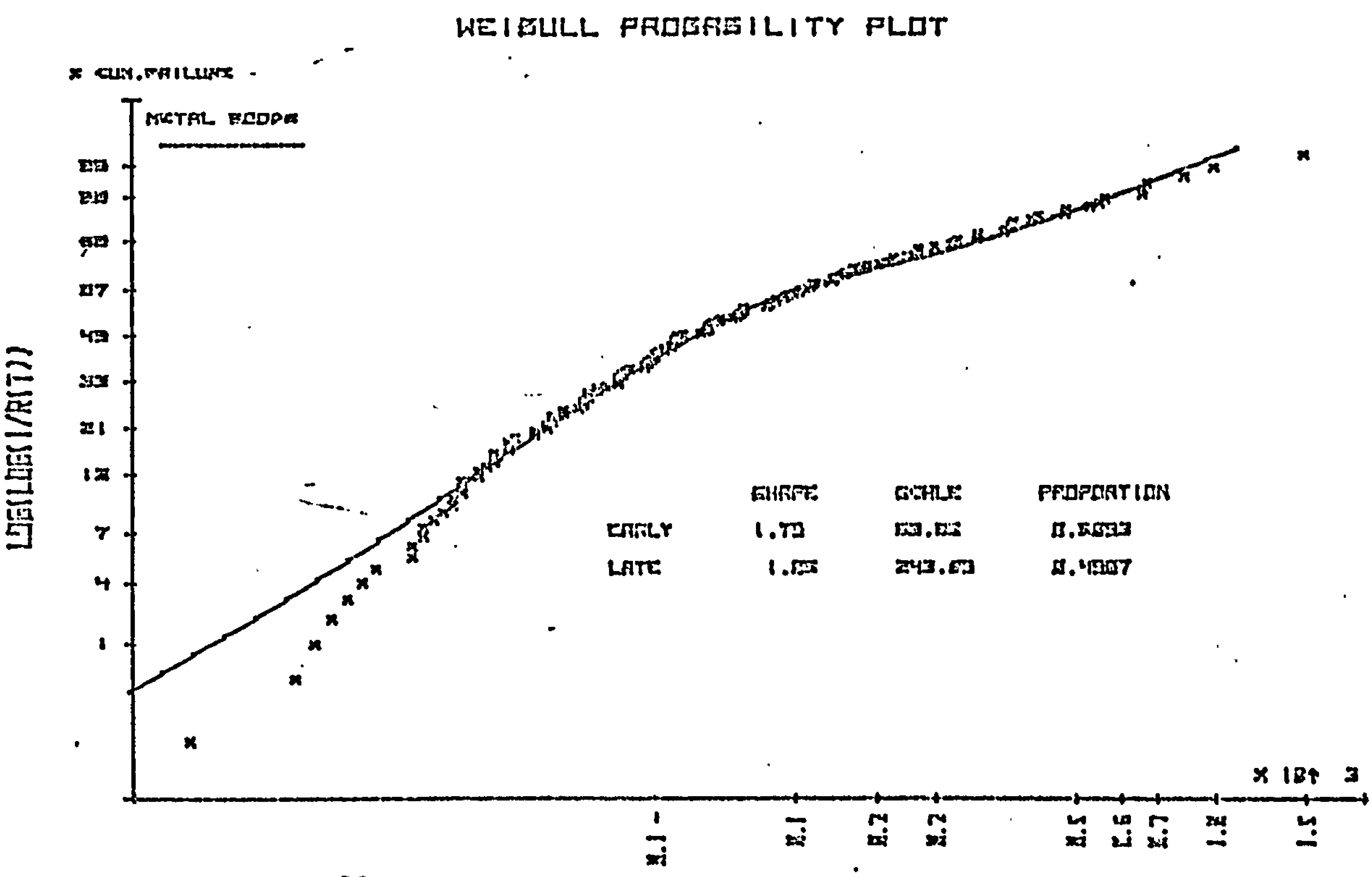


Fig. B.33 LOG TIME

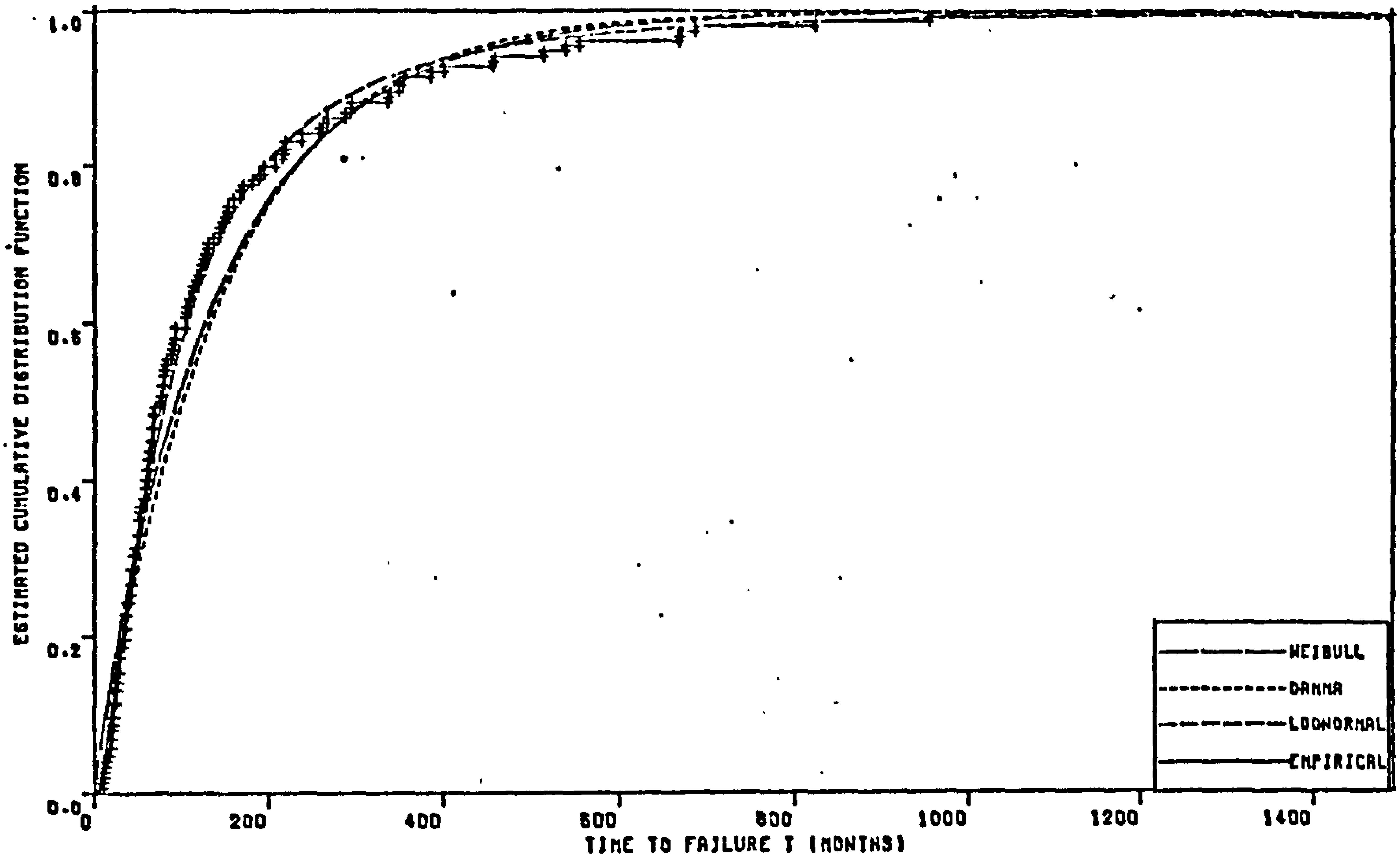


Fig. B.34 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

METAL GOODS

	SHAPE	SCALE
LOG-NORMAL	1.04	4.40
WEIBULL	0.93	140
GAMMA	0.54	270

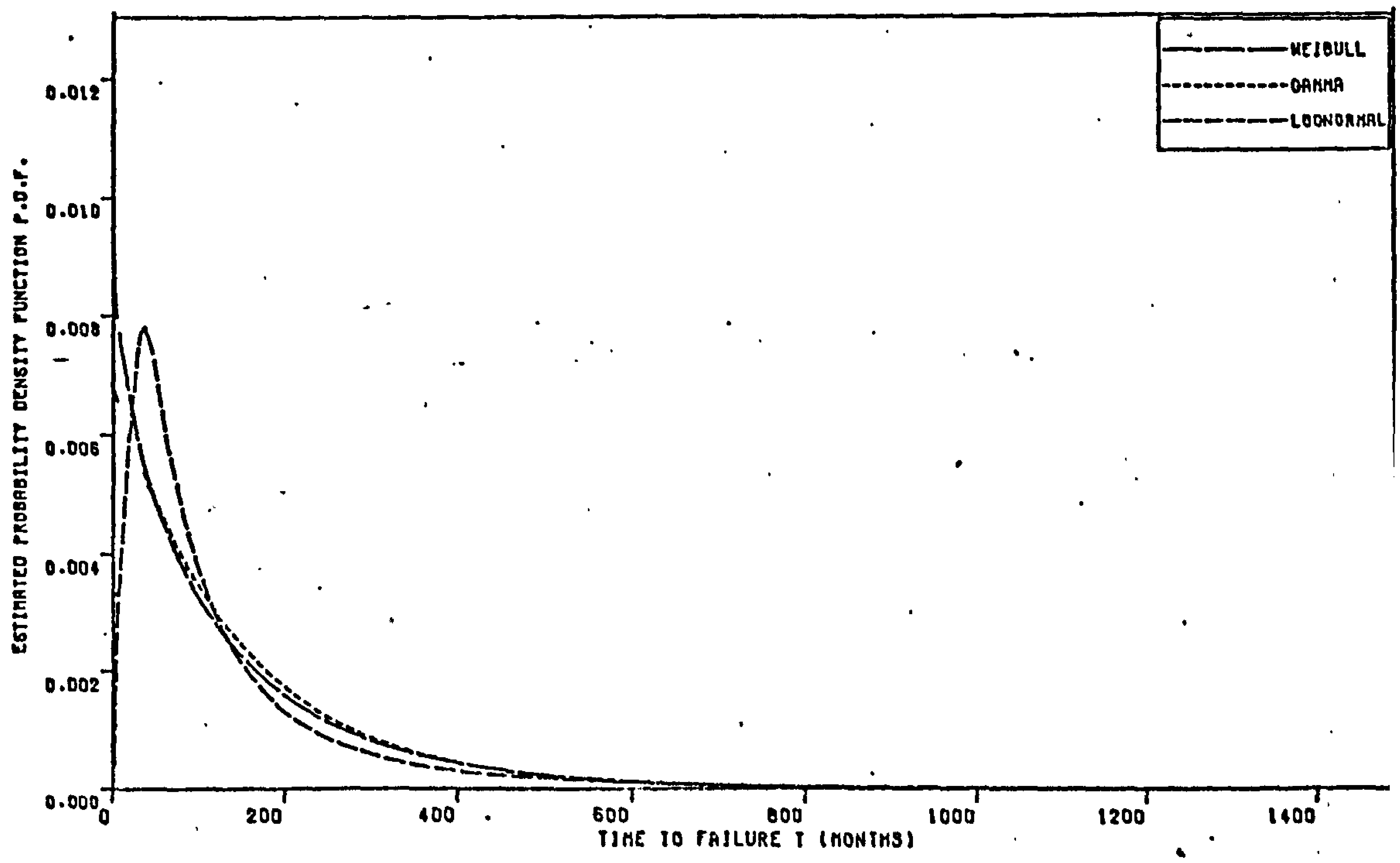


Fig. B.35 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

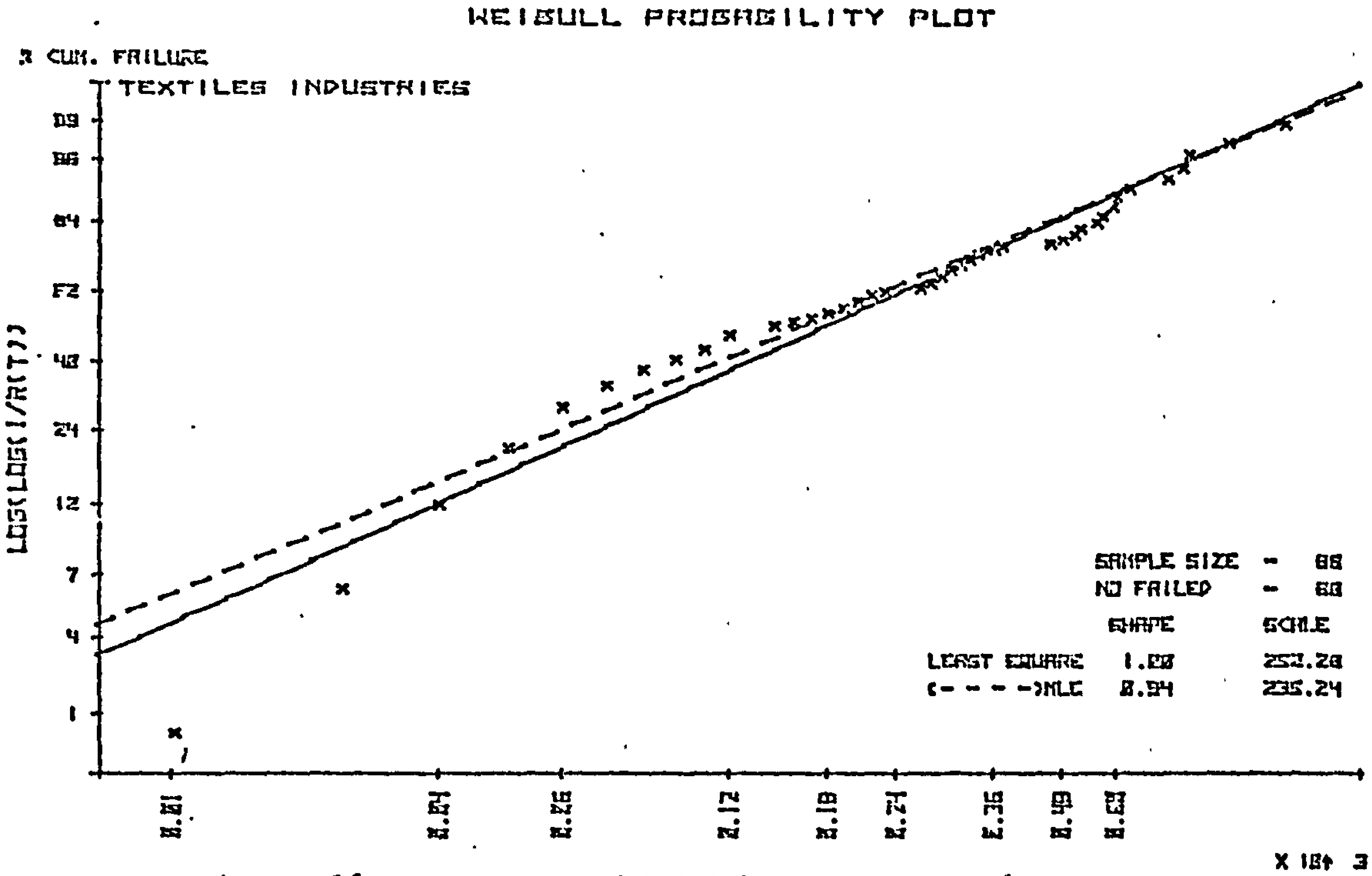


Fig. B.36

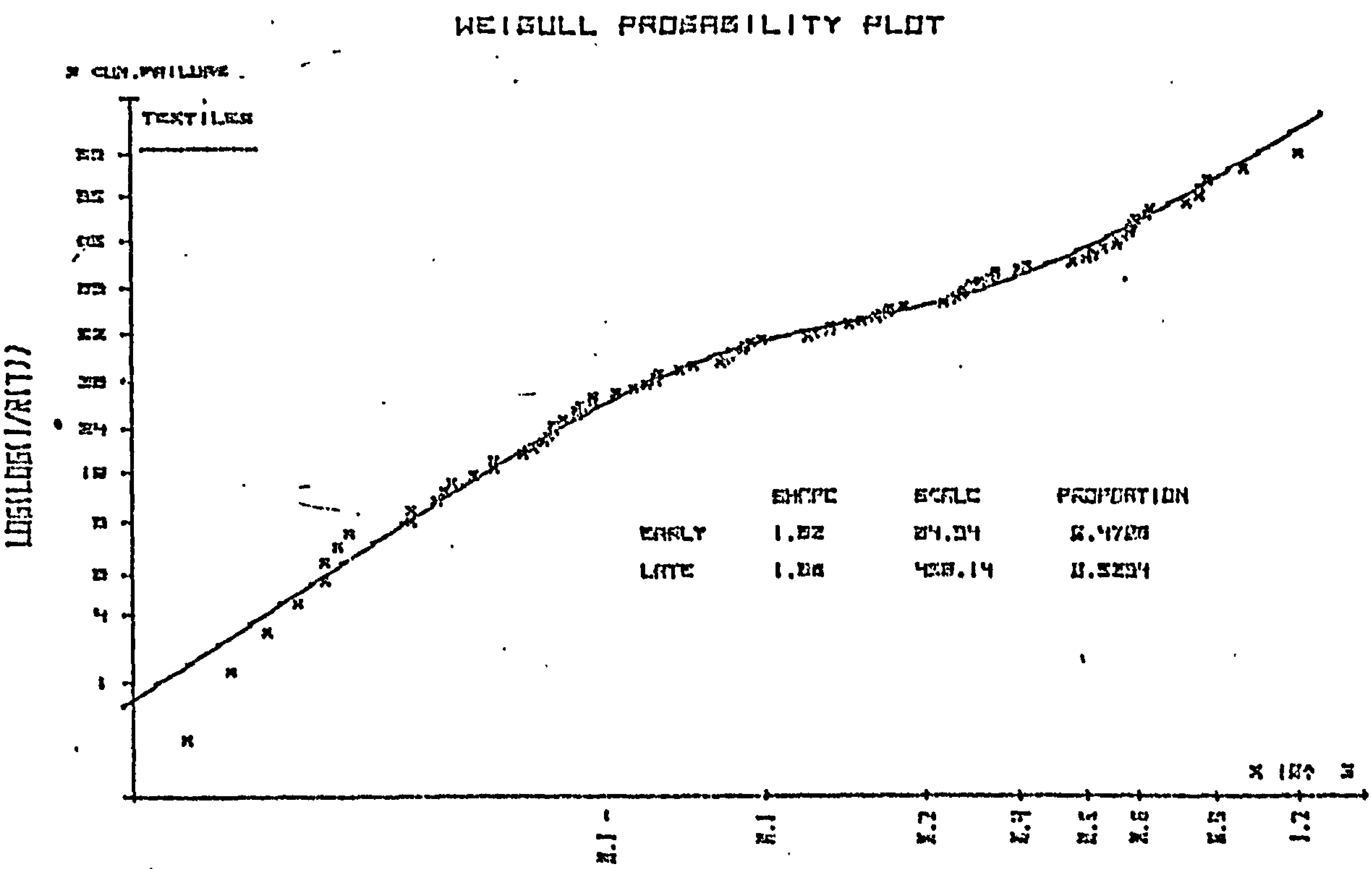


Fig. B.37

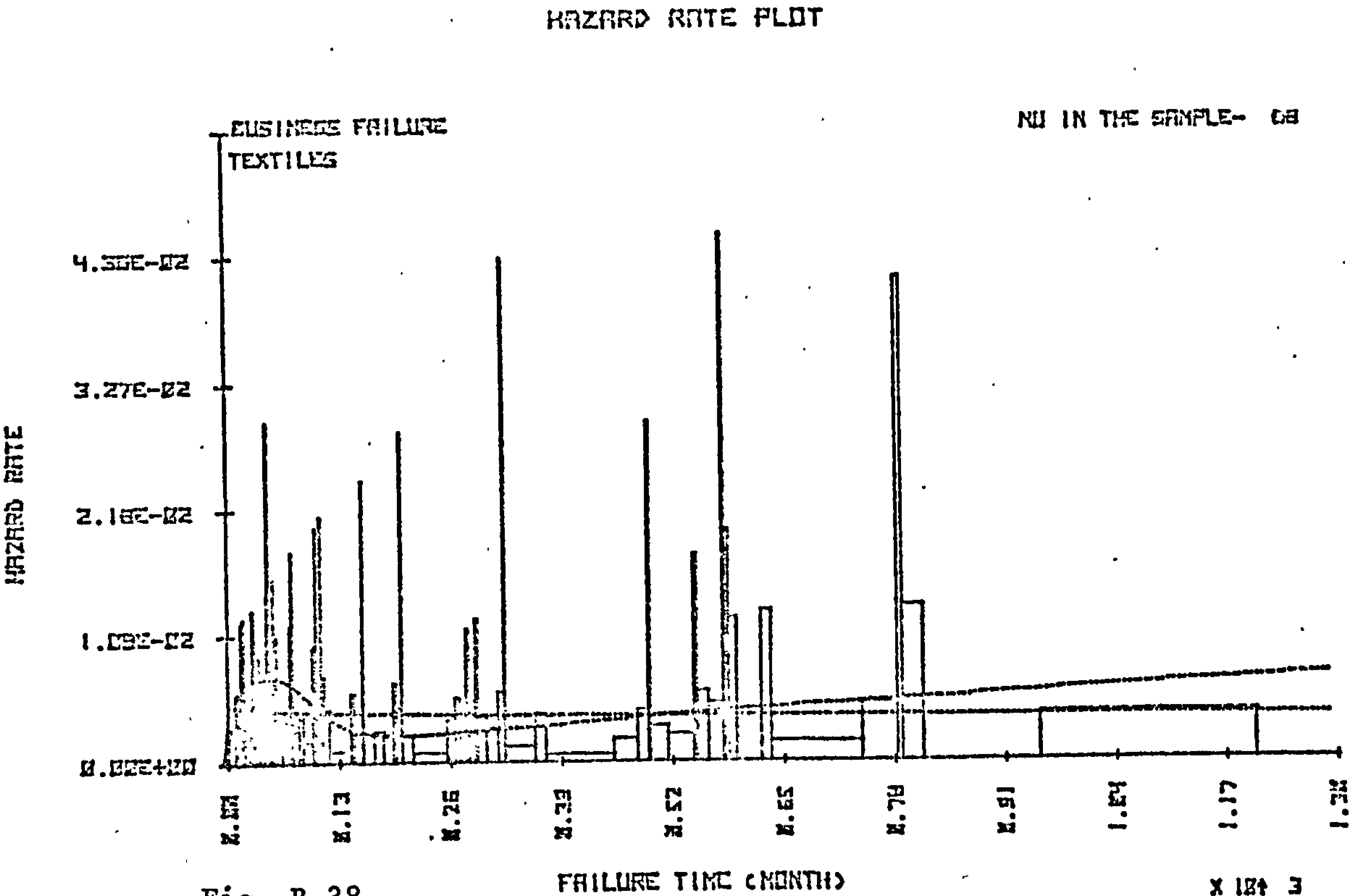


Fig. B.38

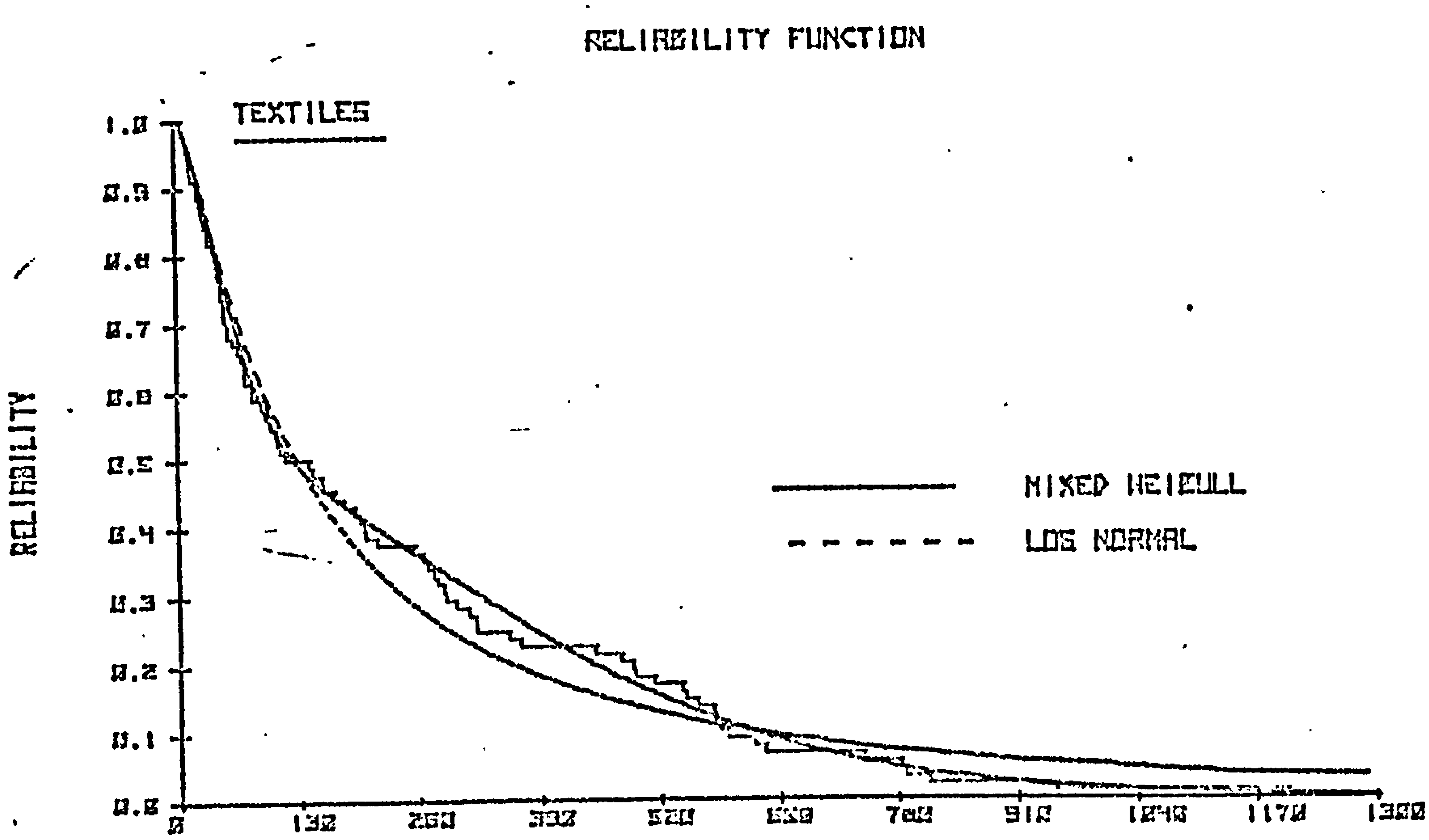


Fig. B.39

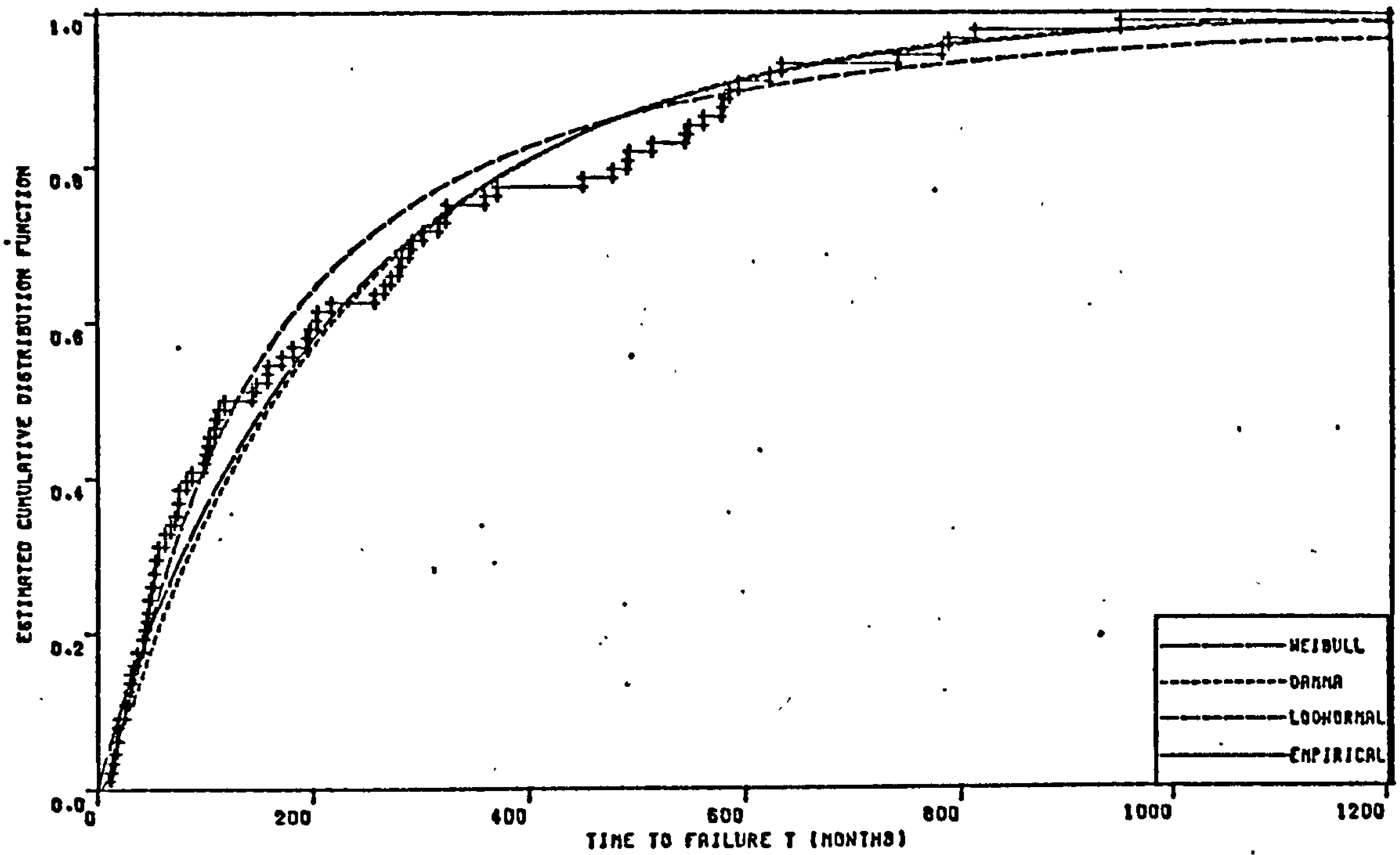


Fig. B.40

FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

TEXTILES

	SHAPE	SCALE
LOG-NORMAL	1.21	4.87
WEIBULL	0.93	235
GAMMA	0.90	268

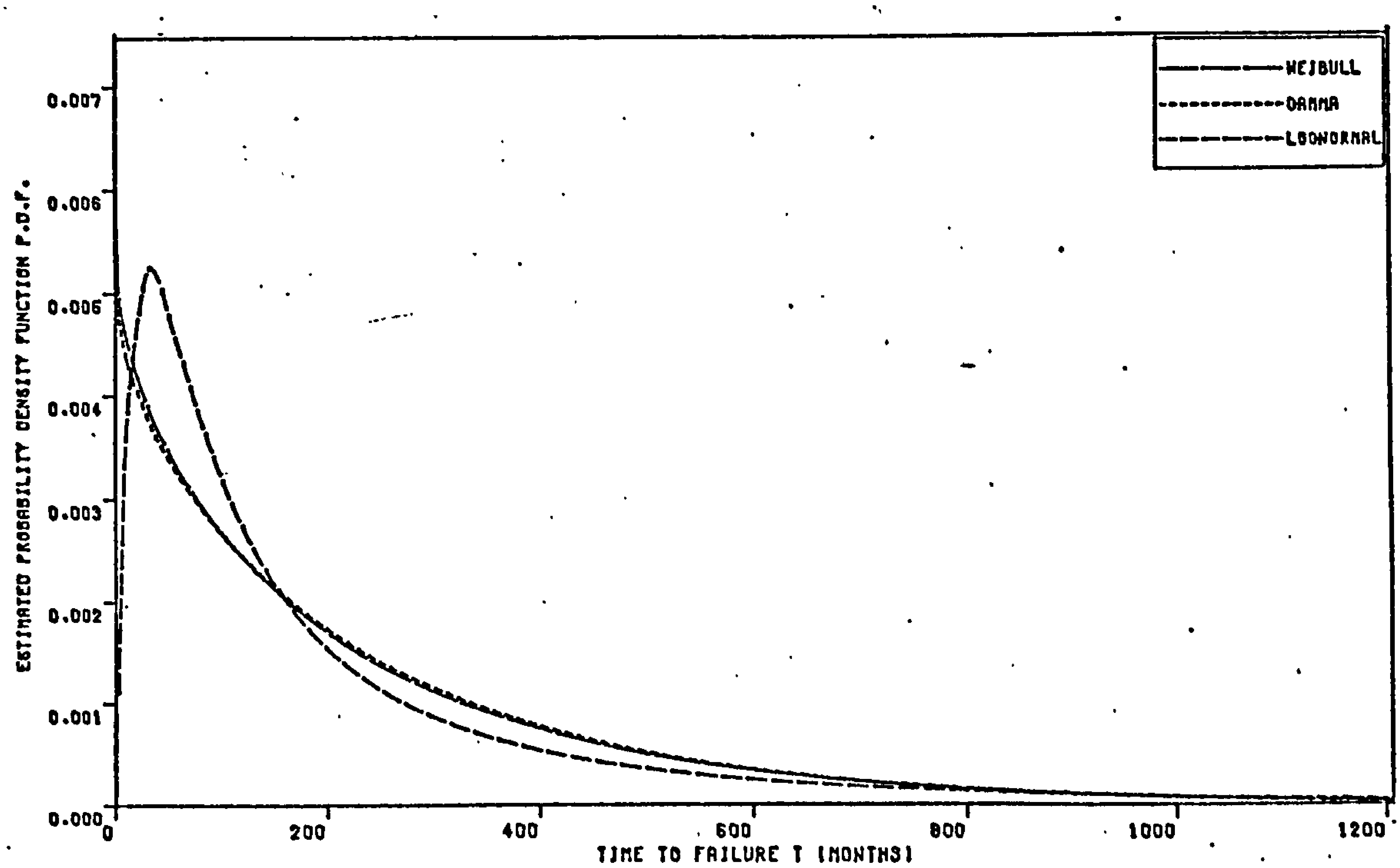


Fig. B.41

FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

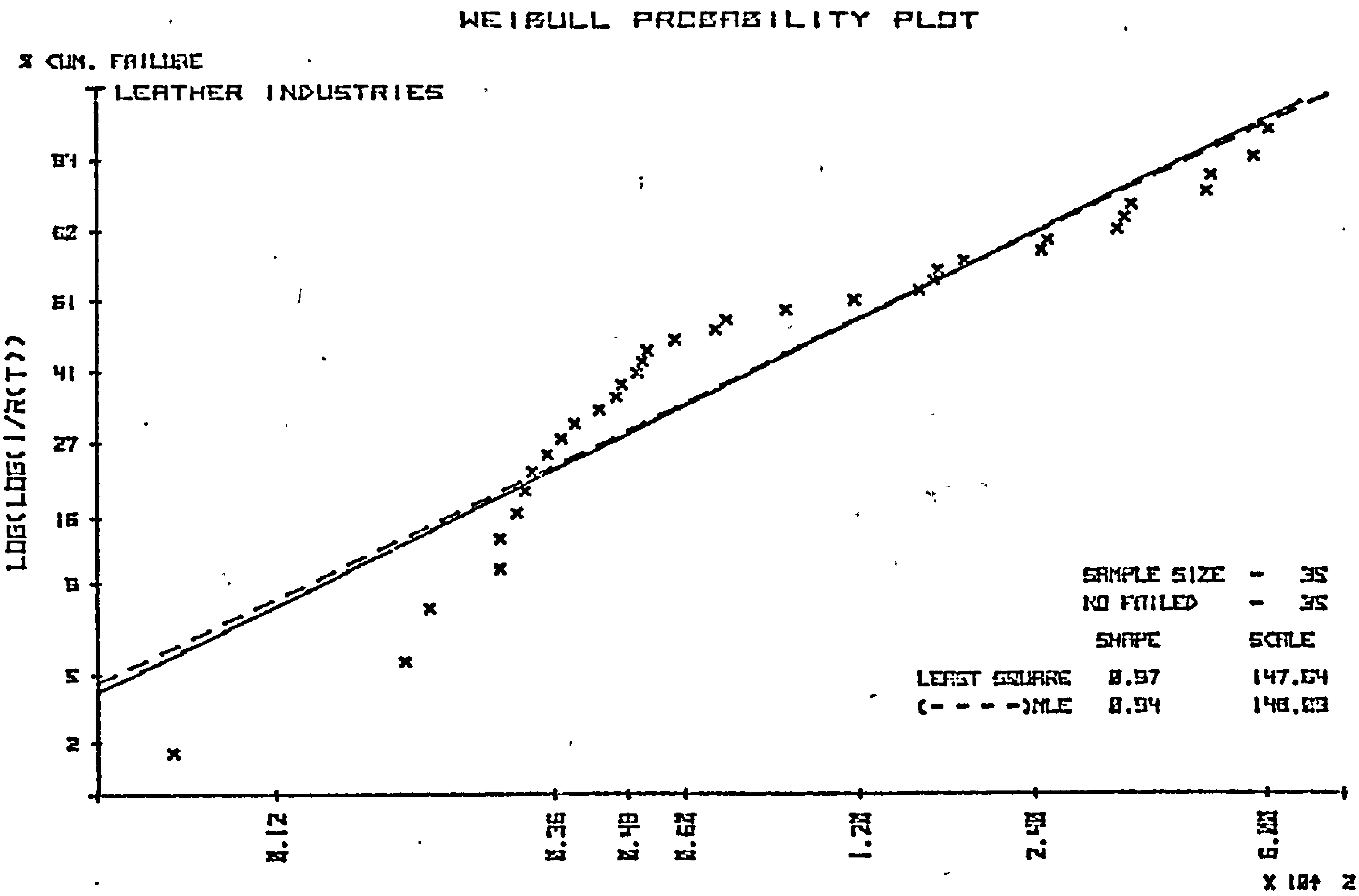


Fig. B.42

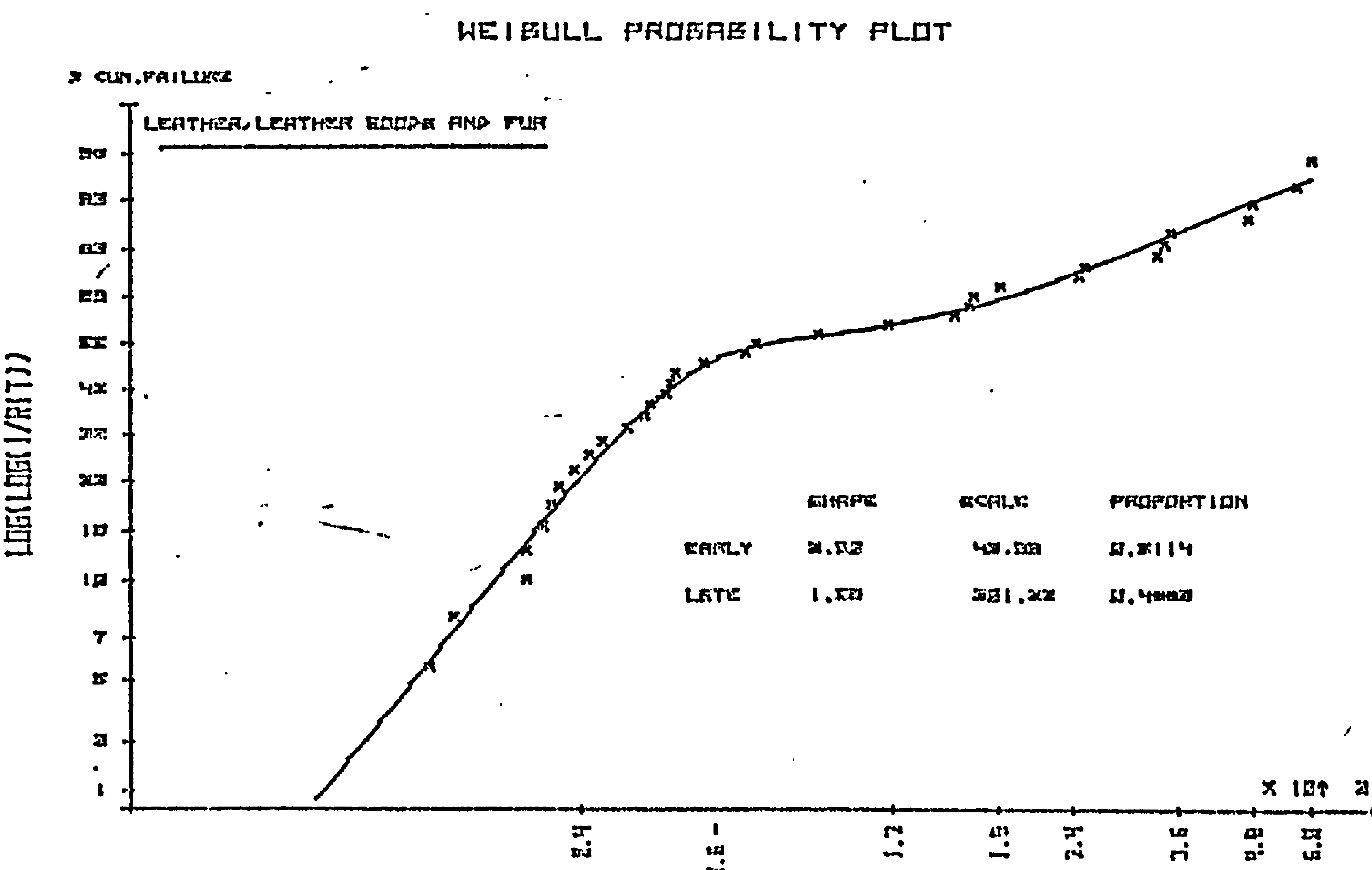


Fig. B.43

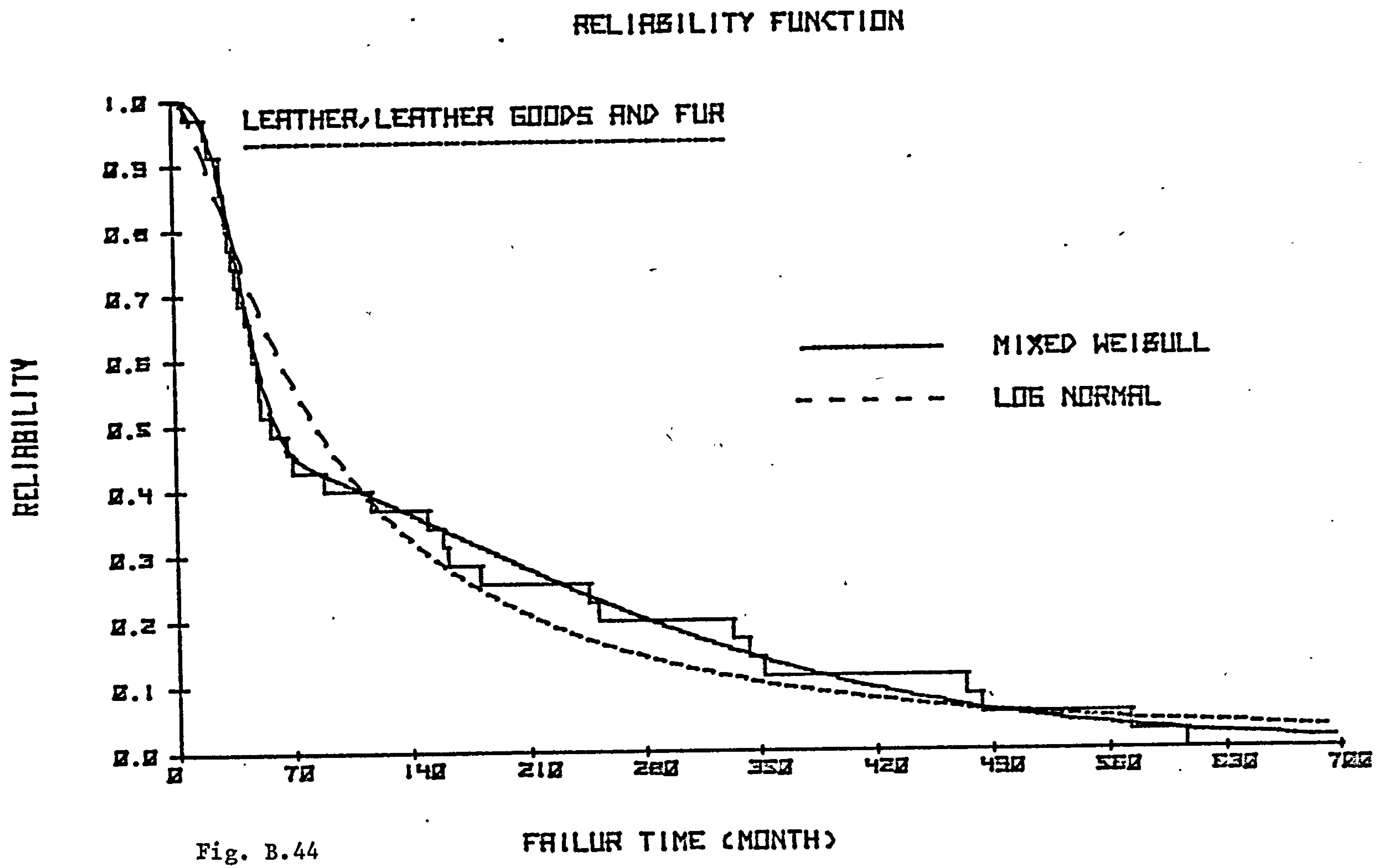

RELIABILITY FUNCTION
LEATHER,LEATHER GOODS AND FUR
MIXED WEIBULL
LOG NORMAL
RELIABILITY
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
70
140
210
280
350
420
490
560
630
700
FAILUR TIME (MONTH)

Fig. B.44

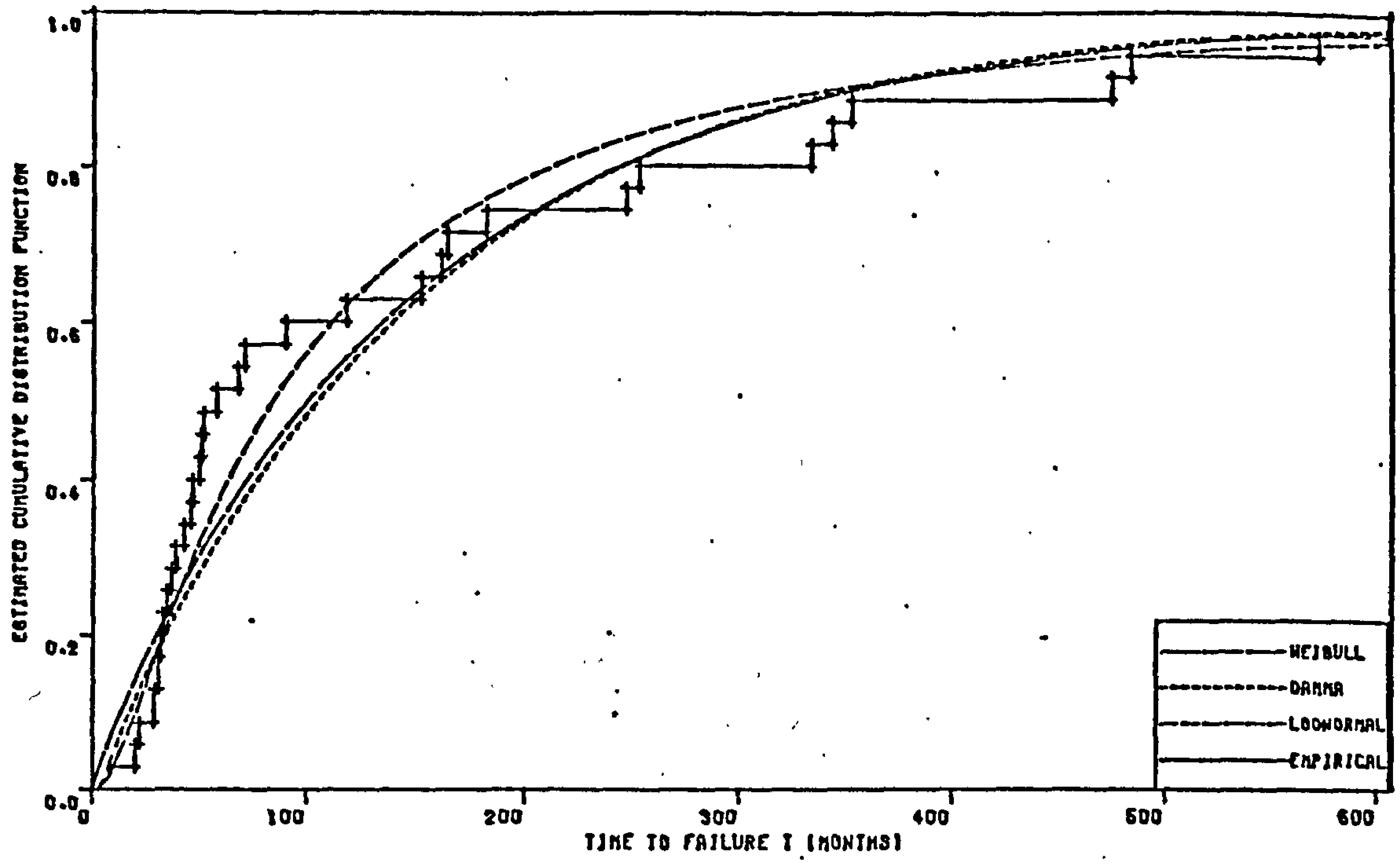


Fig. B.45 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

LEATHER, LEATHER GOODS AND FUR

	SHAPE	SCALE
LOG-NORMAL	1.10	4.43
WEIBULL	0.94	148
GAMMA	0.80	190

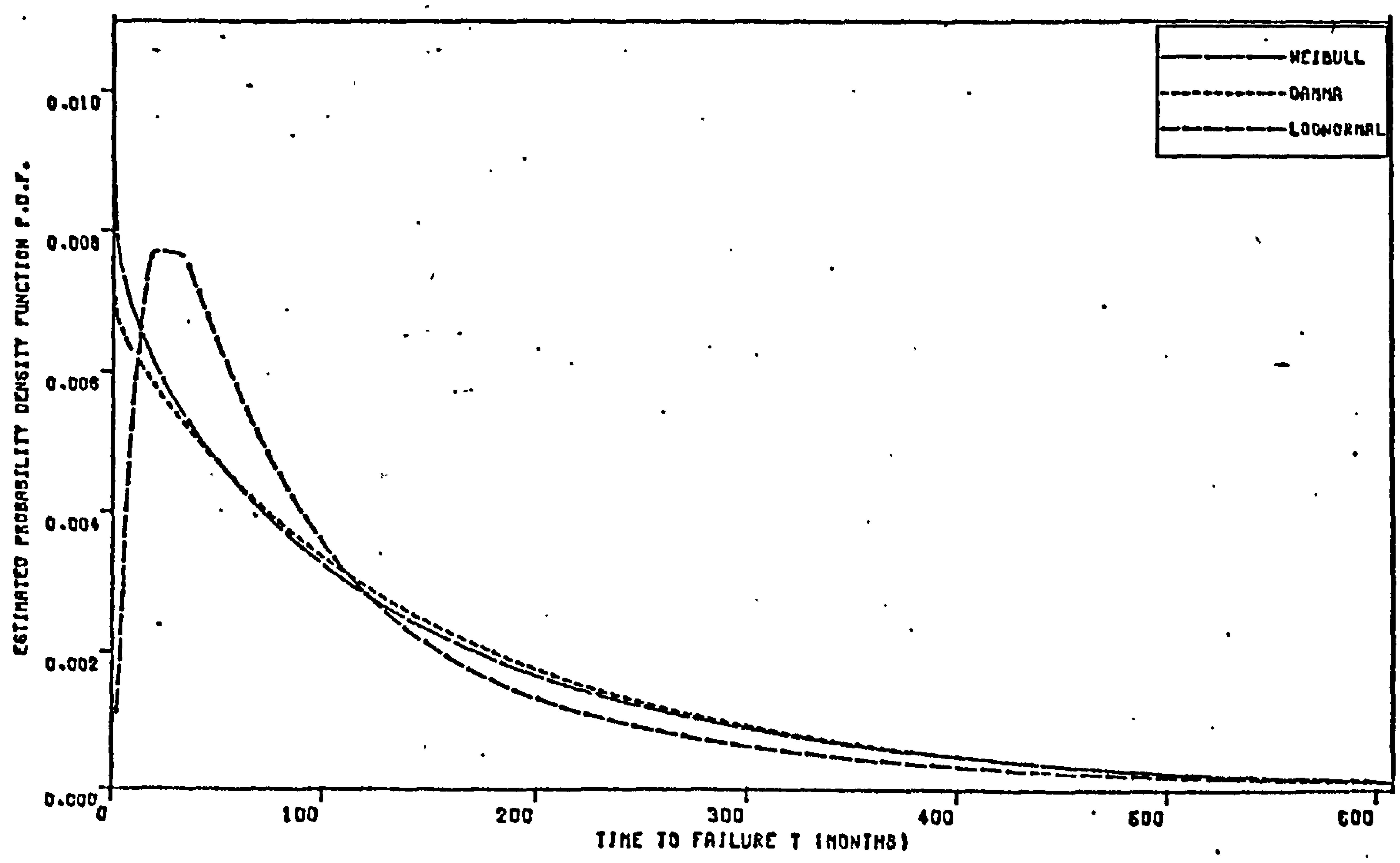
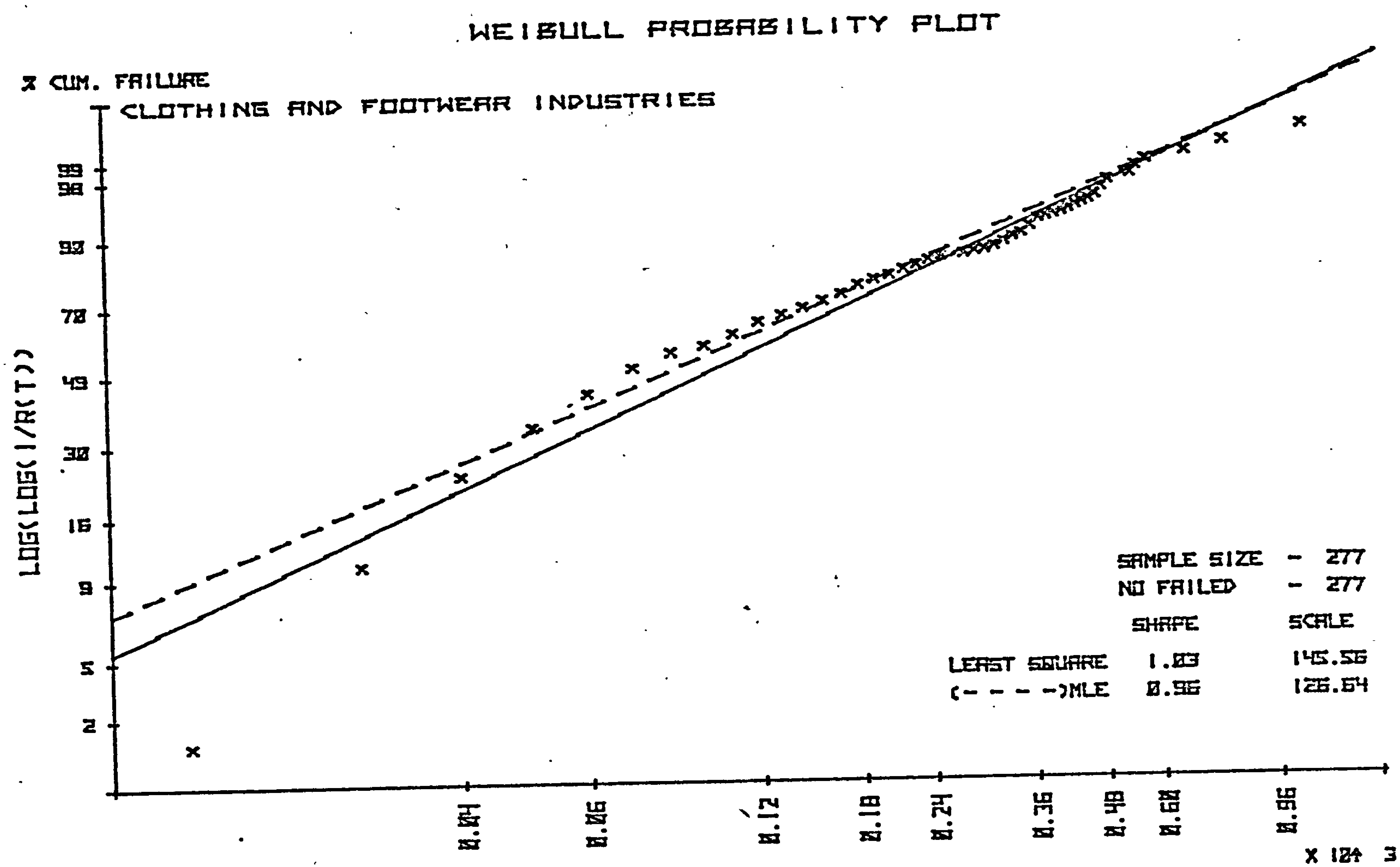


Fig. B.46 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS



WEIBULL PROBABILITY PLOT
% CUM. FAILURE
CLOTHING AND FOOTWEAR INDUSTRIES
99
98
93
70
49
30
16
9
5
2
LOG(LOG(1/R(T))
0.04
0.06
0.12
0.18
0.24
0.36
0.48
0.60
0.96
X 10† 3
LOG(TIME)
SAMPLE SIZE - 277
NO FAILED - 277
SHAPE
SCALE
LEAST SQUARE 1.03 145.56
(- - - -)MLE 0.96 126.64

Fig. B.47

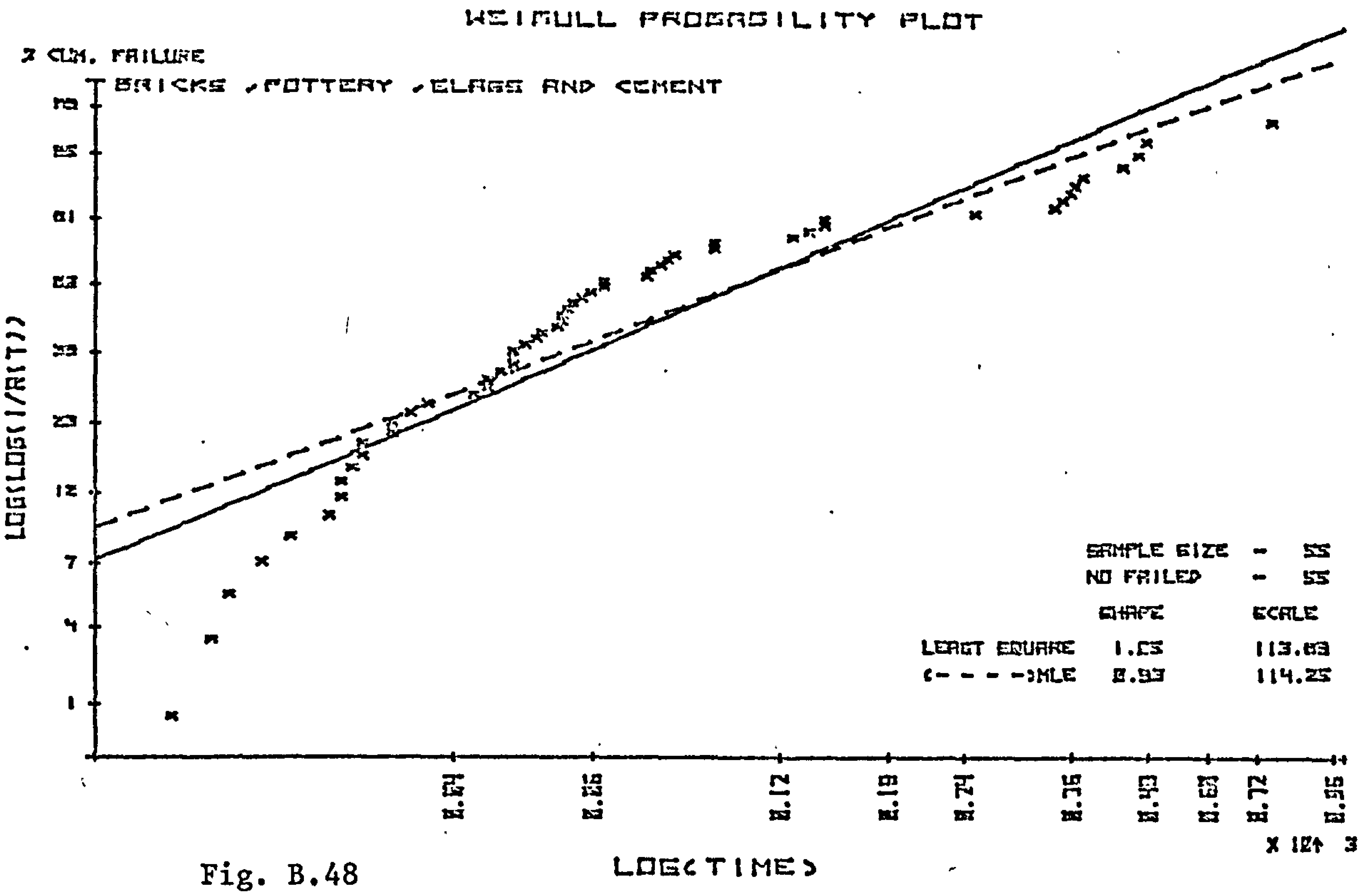


Fig. B.48

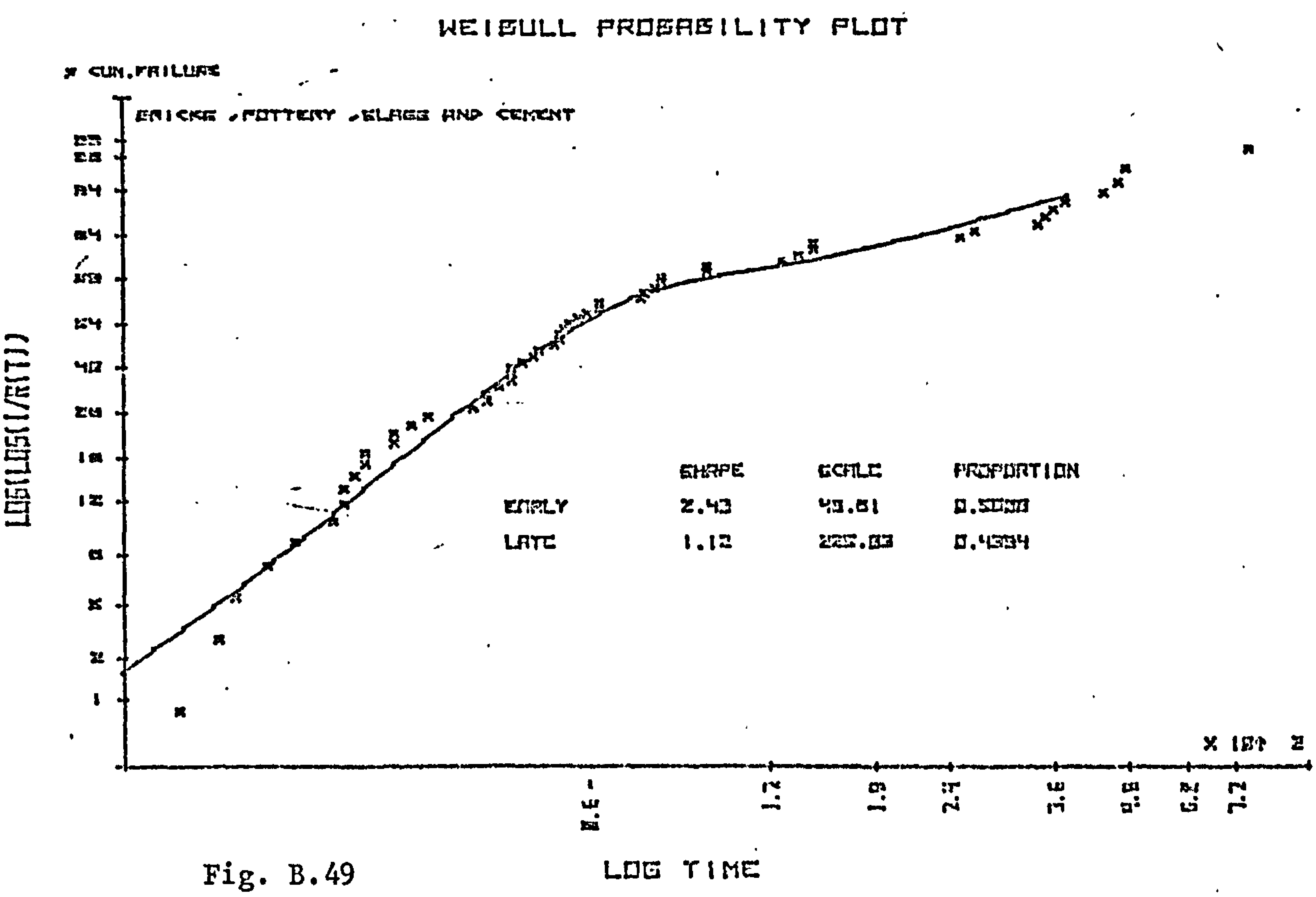


Fig. B.49

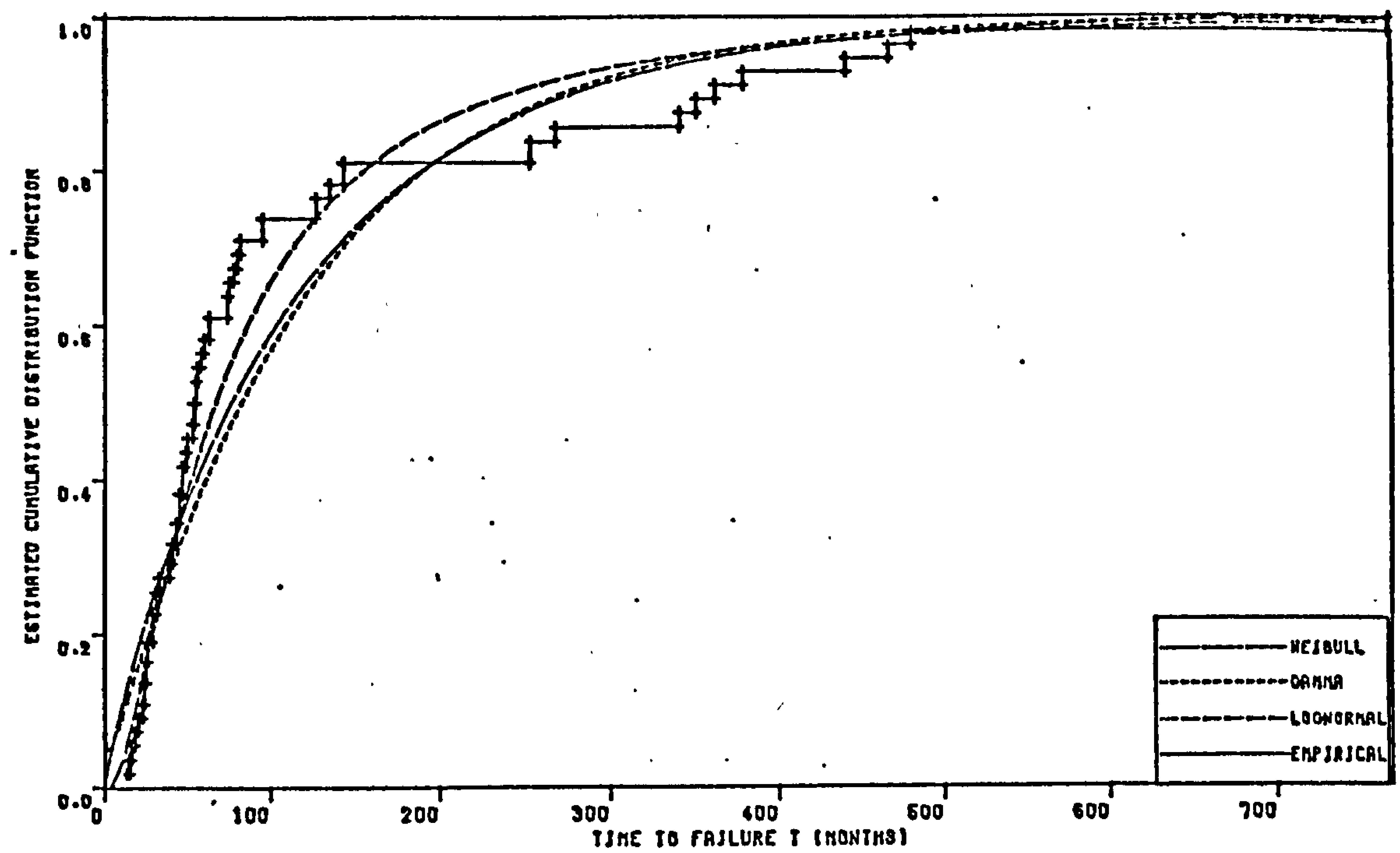


Fig. B.50 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

BRICKS, POTTERY, GLASS, CEMENT, ETC.

	SHAPE	SCALE
LOG-NORMAL	1.00	4.21
WEIBULL	0.93	114
GAMMA	0.59	200

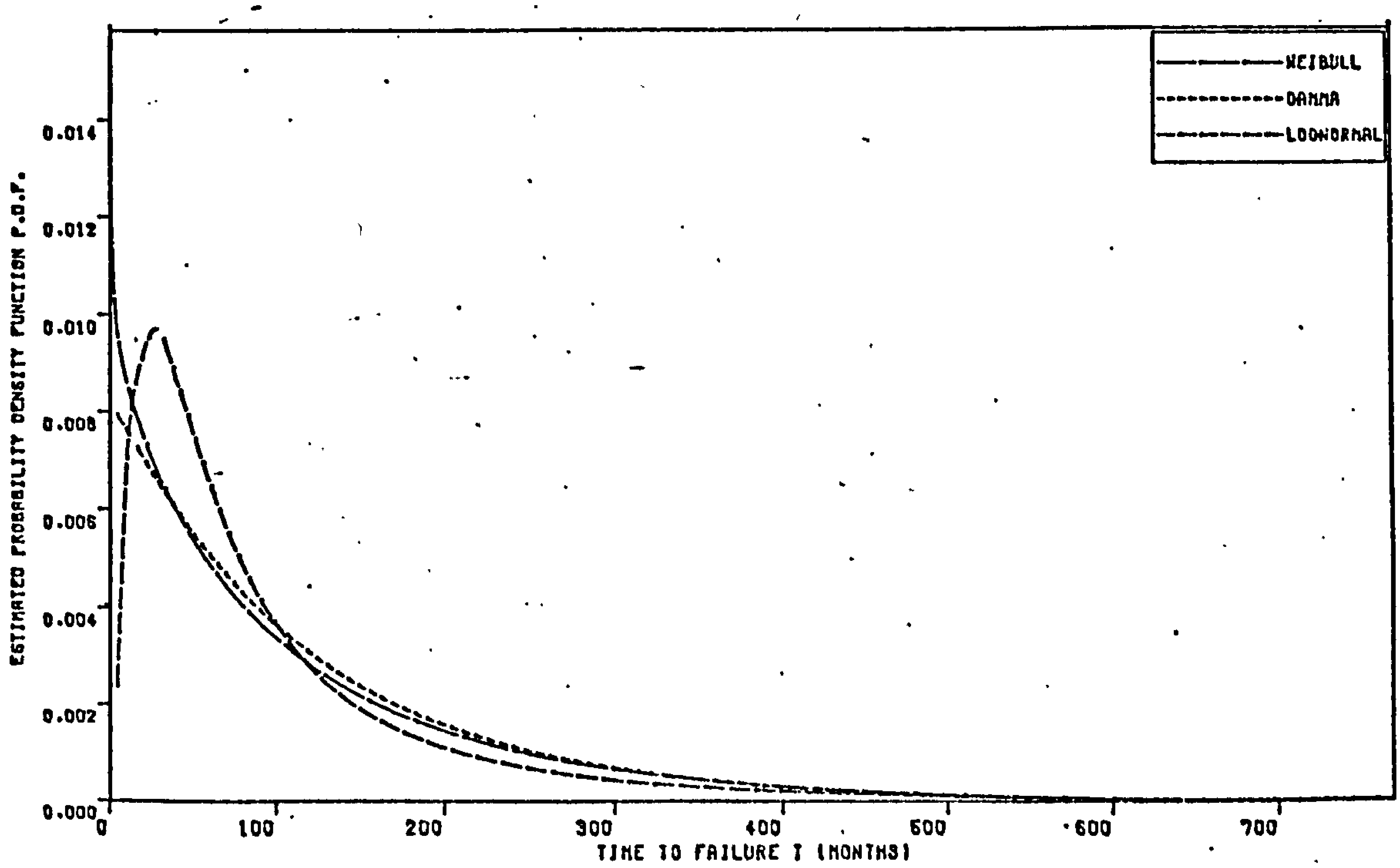


Fig. B.51 FID : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

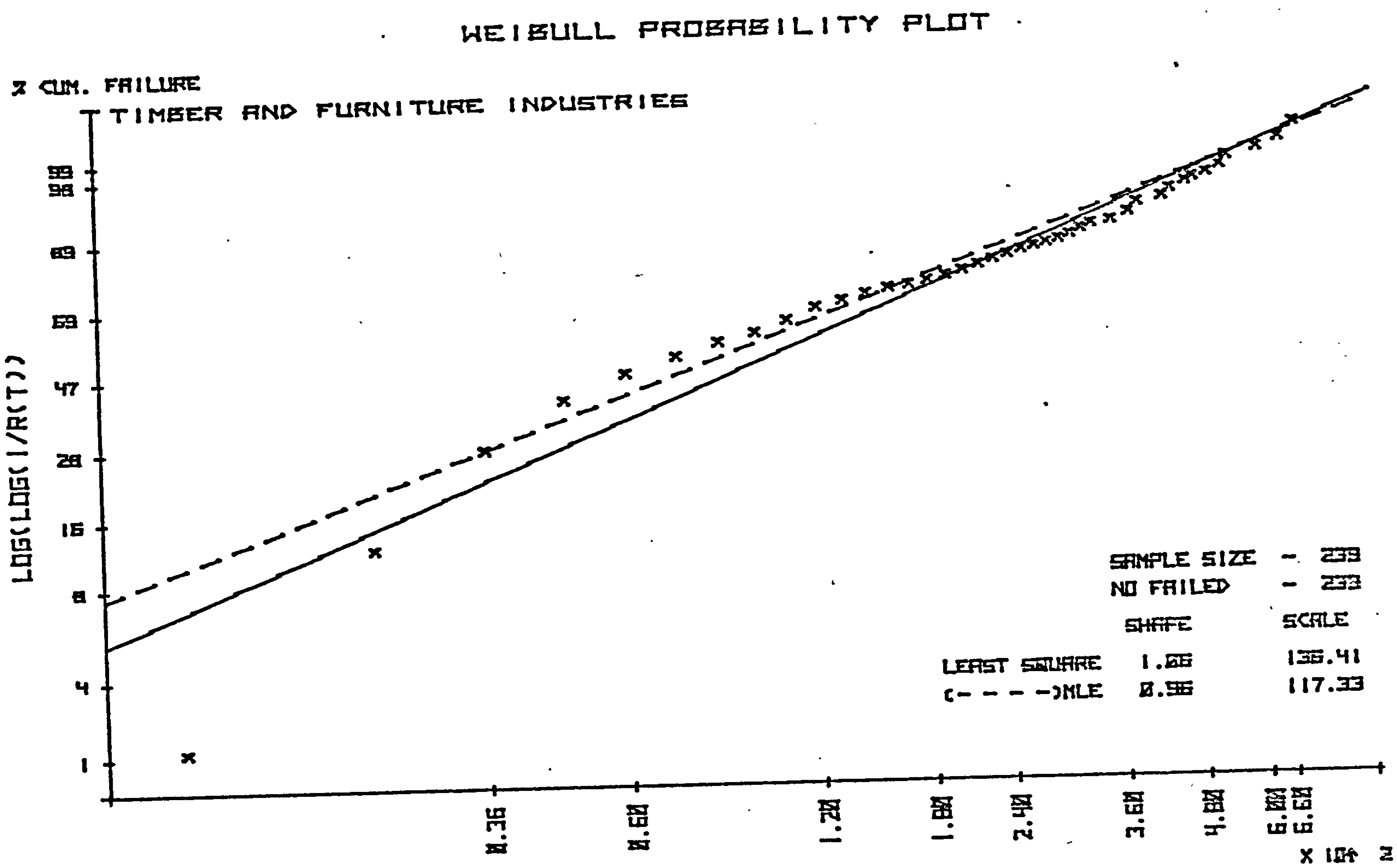

WEIBULL PROBABILITY PLOT
% CUM. FAILURE
TIMBER AND FURNITURE INDUSTRIES
LOG(LOG(1/R(T))
99
98
89
63
47
28
15
8
4
1
0.36
0.60
1.20
1.80
2.40
3.60
4.80
6.00
6.60
X 10^ 2
LOG(TIME)
SAMPLE SIZE - 233
NO FAILED - 233
SHAPE
SCALE
LEAST SQUARE 1.06 136.41
(- - - -)MLE 0.96 117.33

Fig. B.52

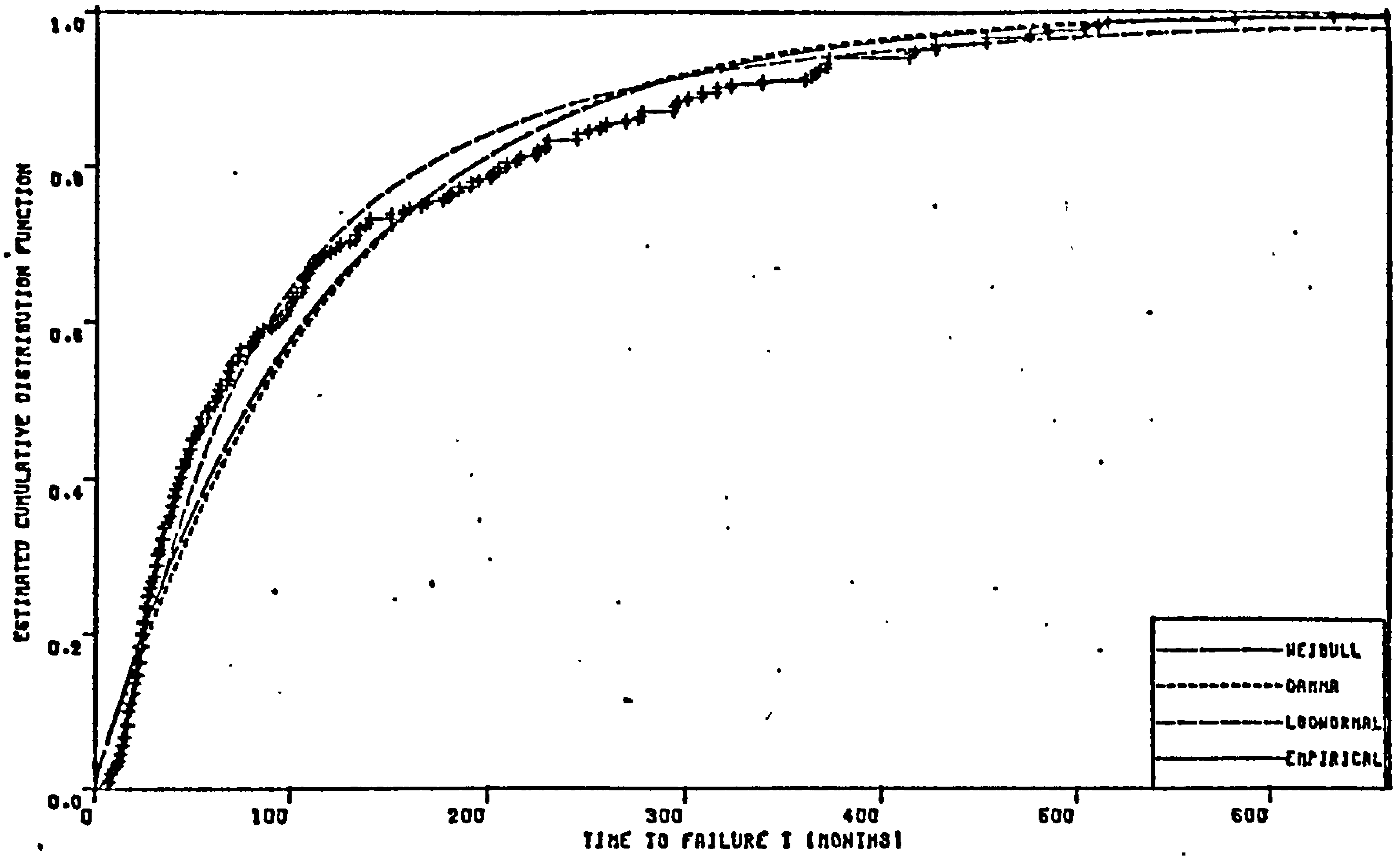


Fig. B.53 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

TIMBER, FURNITURE ETC.,

	SHAPE	SCALE
LOG-NORMAL	1.09	4.21
WEIBULL	0.96	117
GAMMA	0.80	149

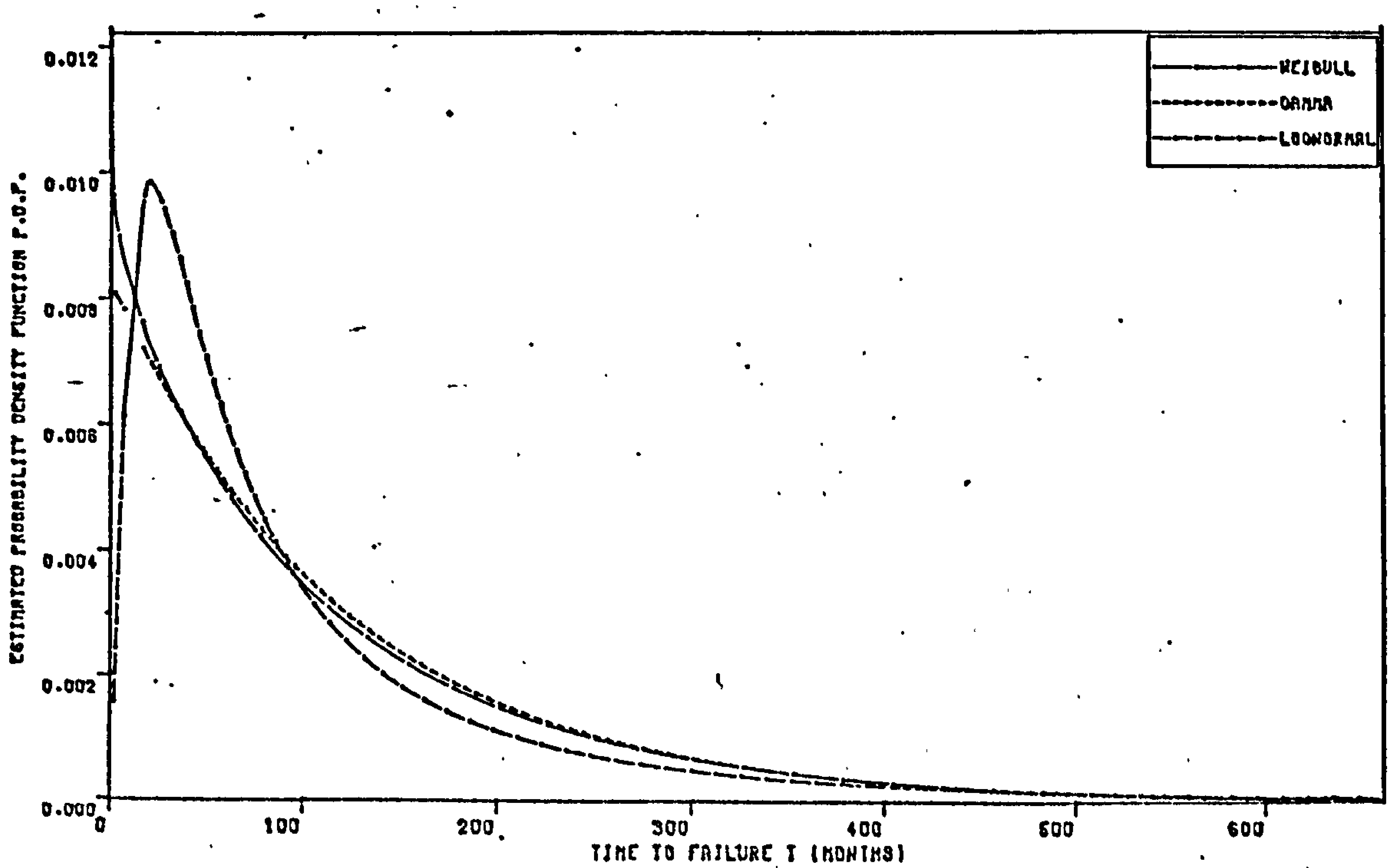


Fig. B.54 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

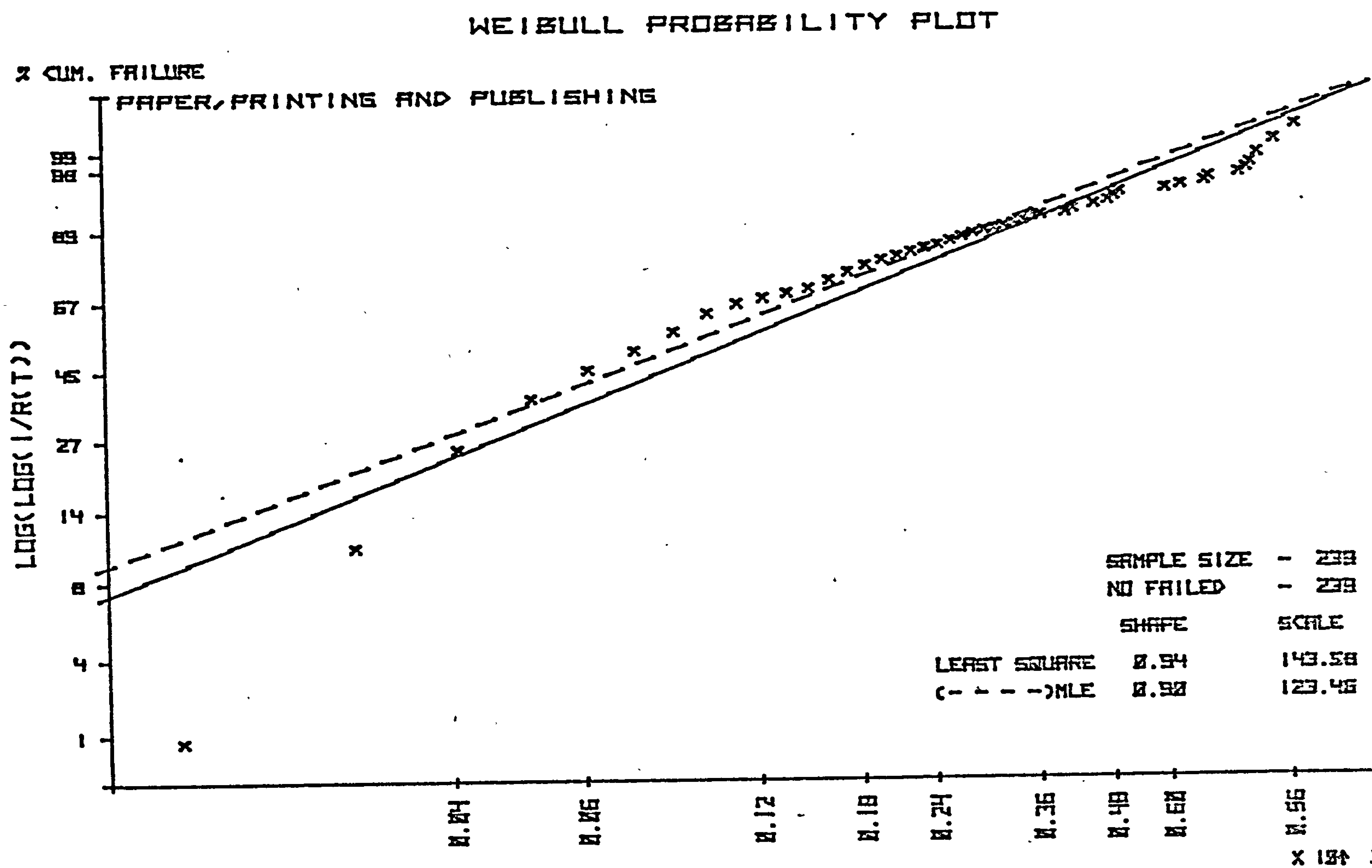

WEIBULL PROBABILITY PLOT
% CUM. FAILURE
PAPER/PRINTING AND PUBLISHING
99
98
89
67
45
27
14
8
4
1
LOG(LOG(1/R(T))
0.04
0.06
0.12
0.18
0.24
0.36
0.48
0.60
0.96
X 10↑ 3
LOG(TIME)
SAMPLE SIZE - 239
NO FAILED - 239
SHAPE
SCALE
LEAST SQUARE 0.54 143.58
(- - - -)MLE 0.58 123.45

Fig. B.55

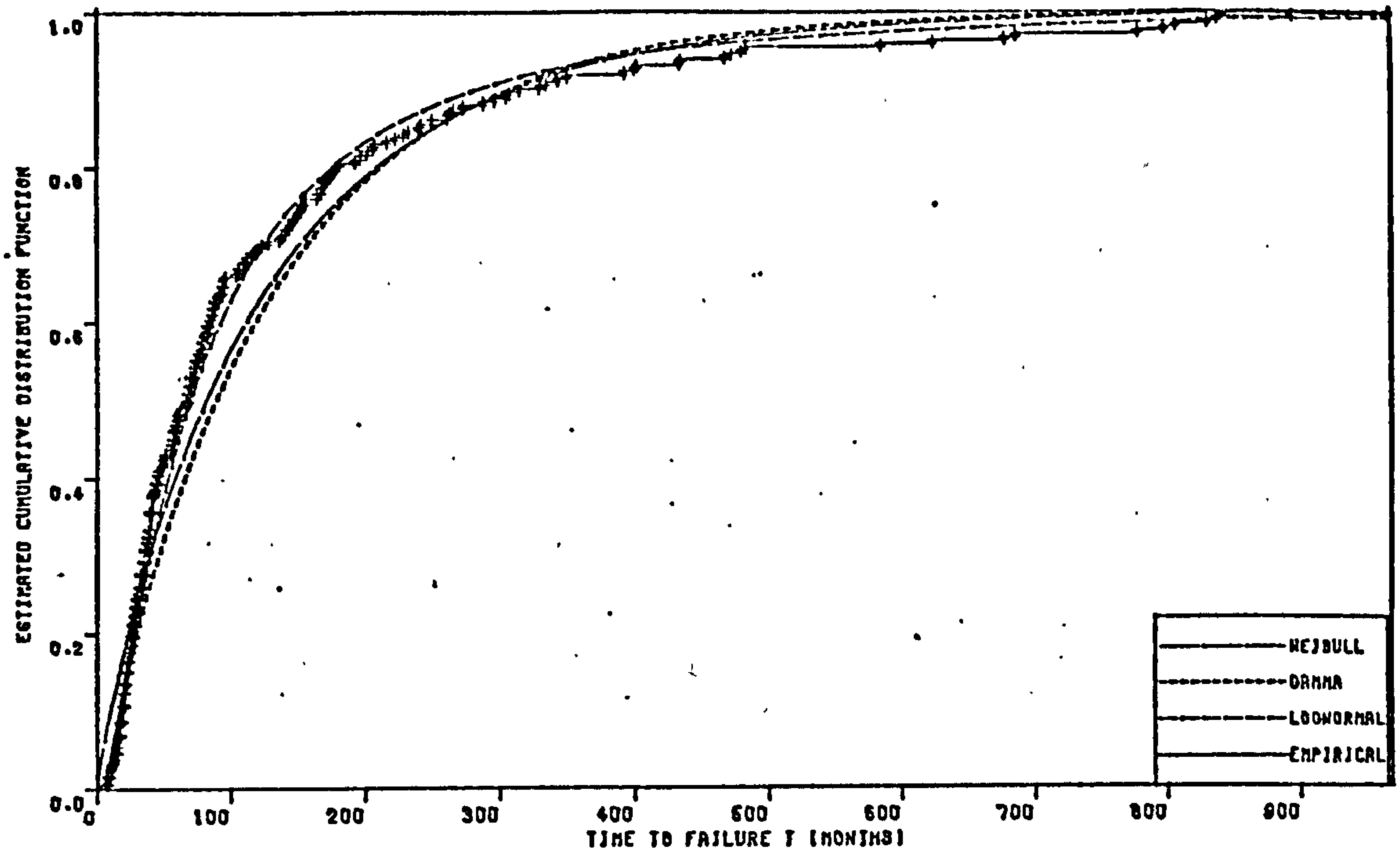


Fig. B.56 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

PAPER, PRINTING AND PUBLISHING

	SHAPE	SCALE
LOG-NORMAL	1.09	4.25
WEIBULL	0.89	123
GAMMA	0.56	235

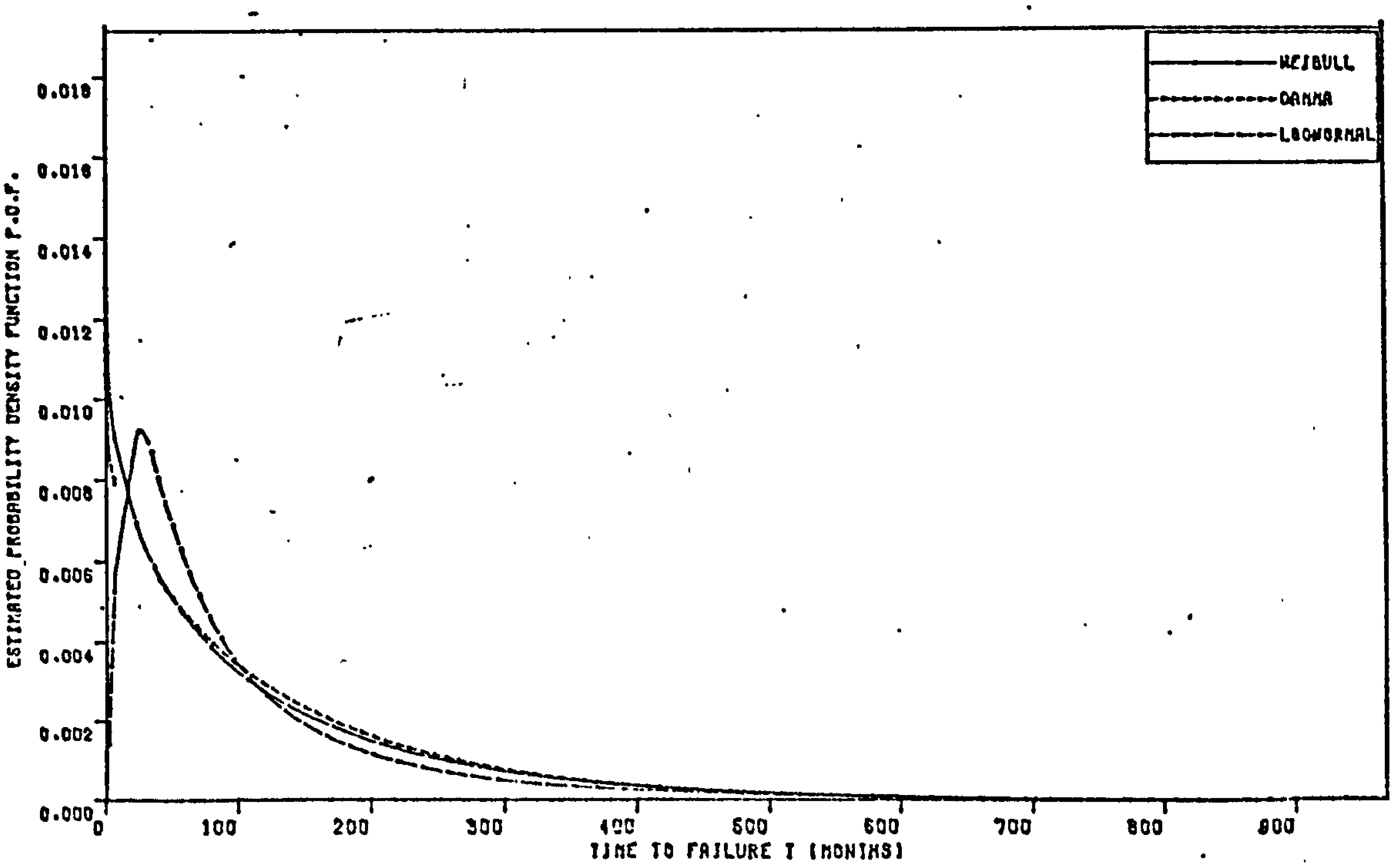


Fig. B.57 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

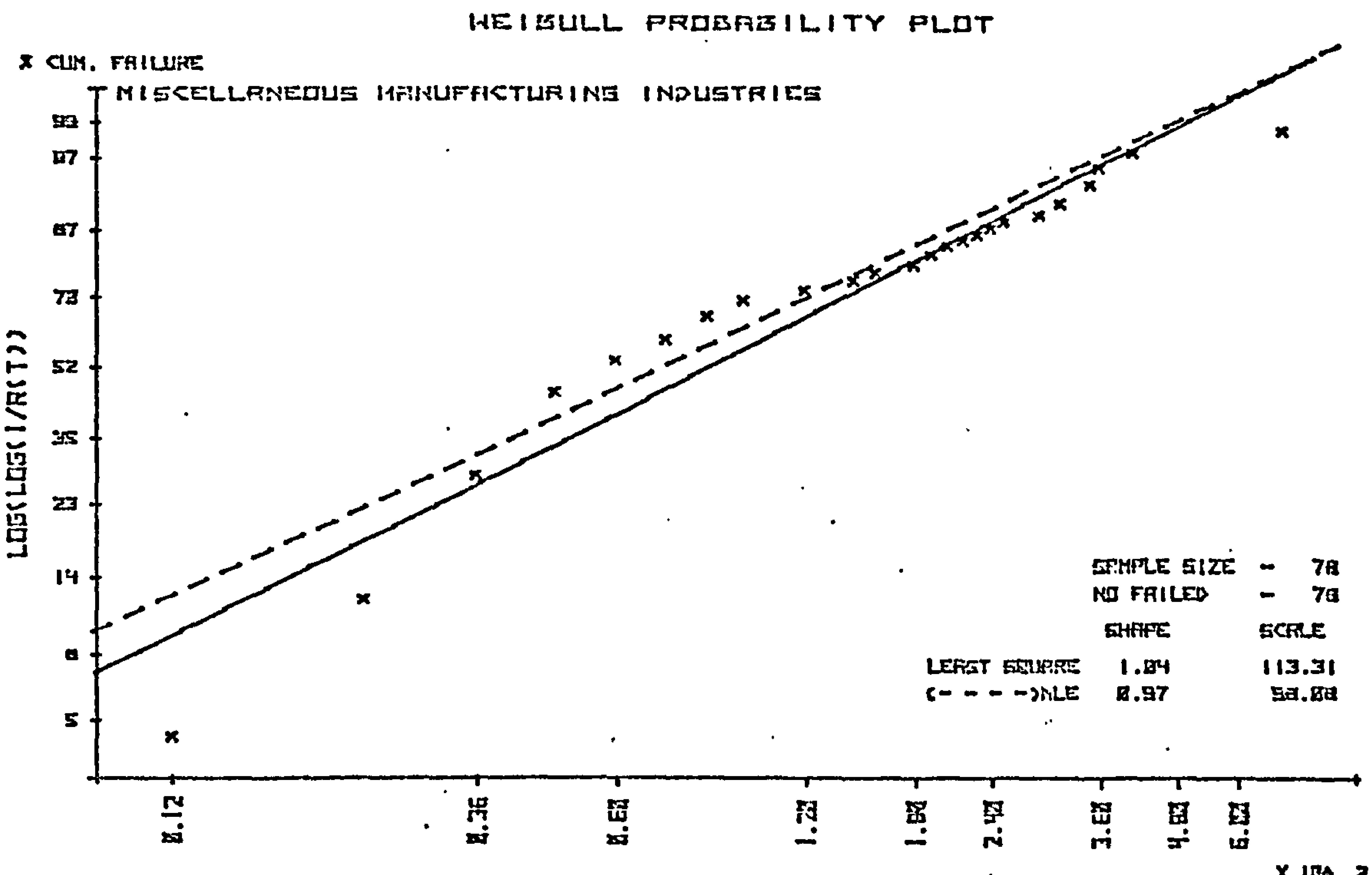


Fig. B.58

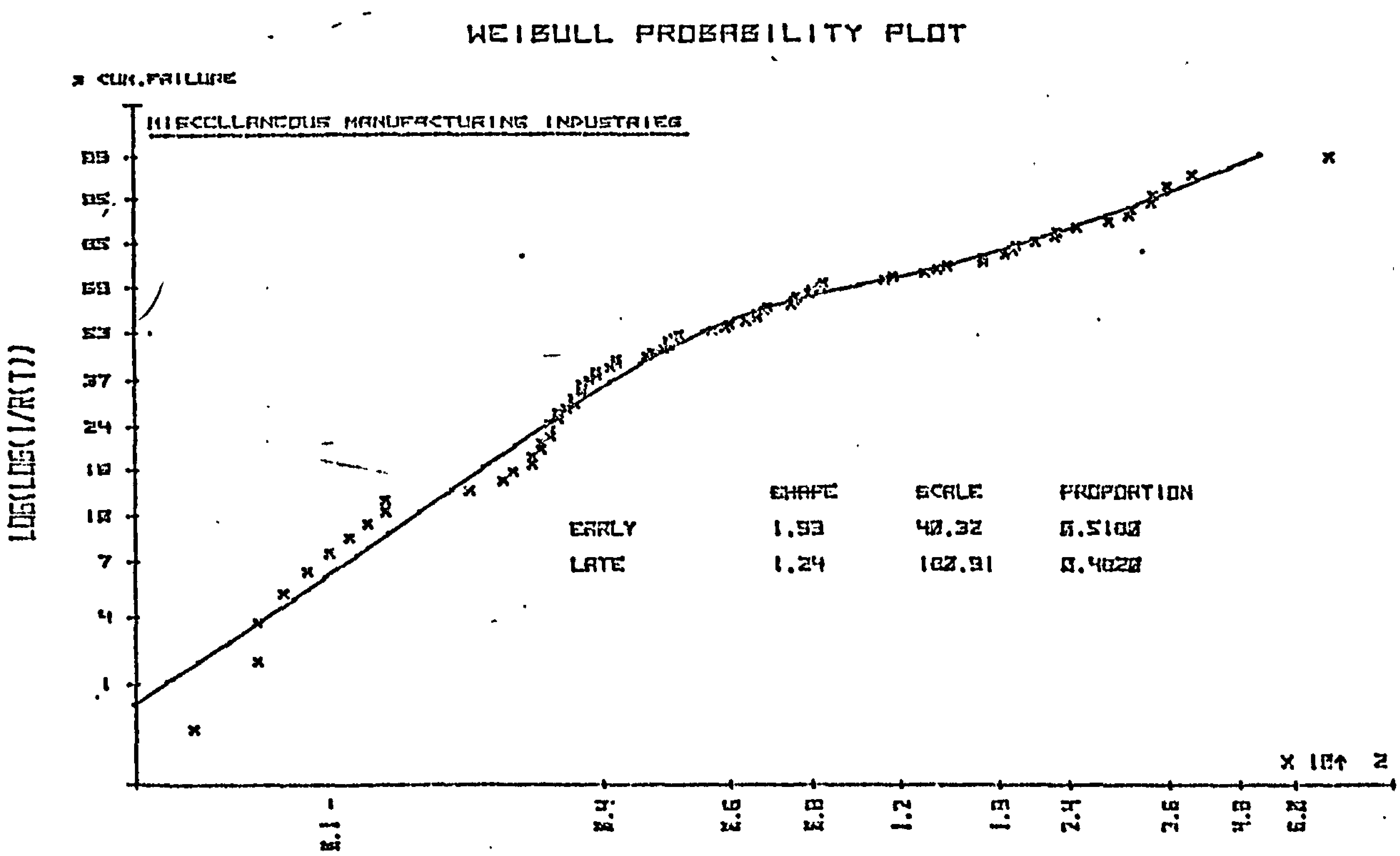
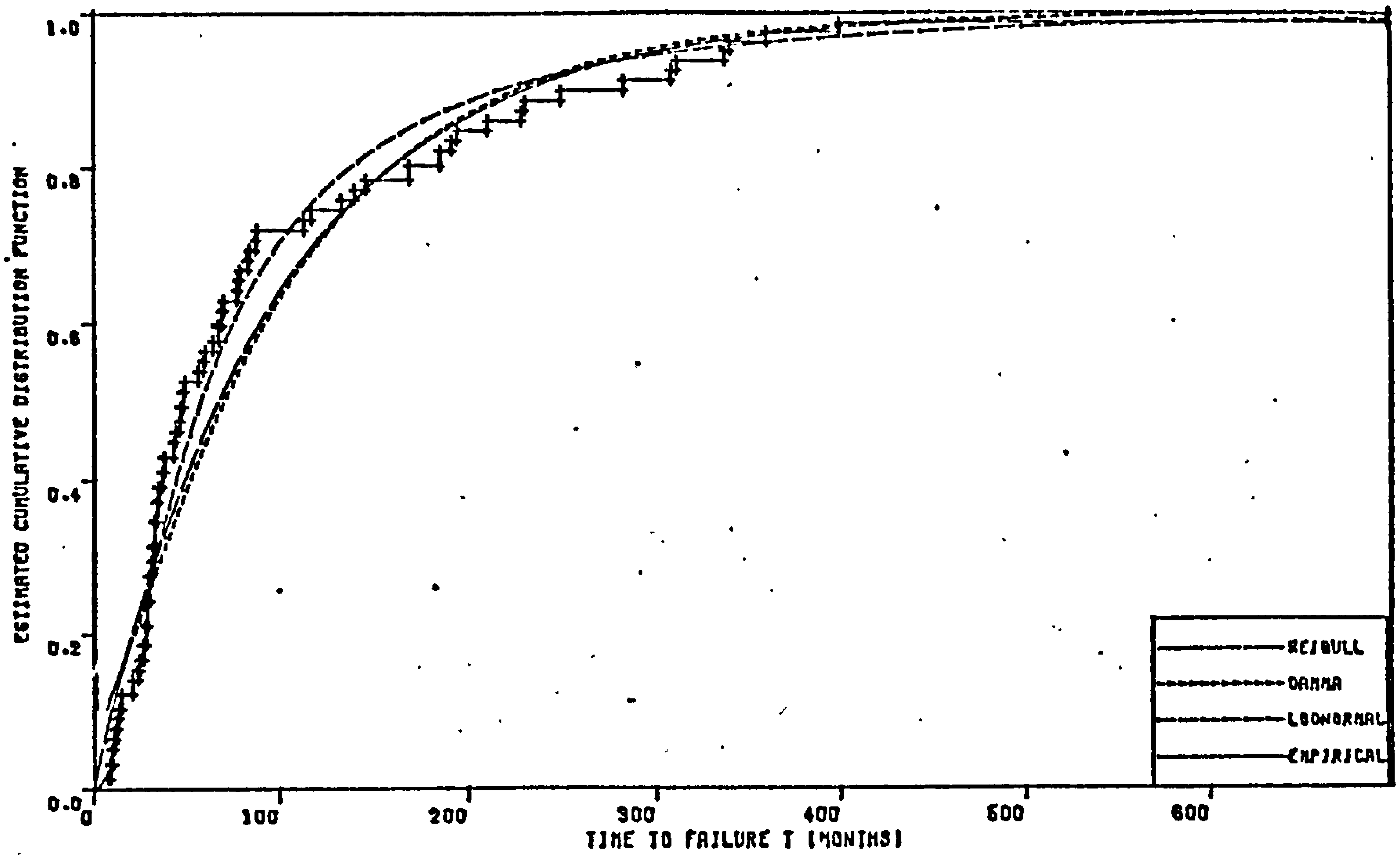


Fig. B.59



F ig. B.60

FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

OTHER MANUFACTURING INDUSTRIES

	SHAPE	SCALE
LOG-NORMAL	1.04	4.05
WEIBULL	0.97	98
GAMMA	0.70	141

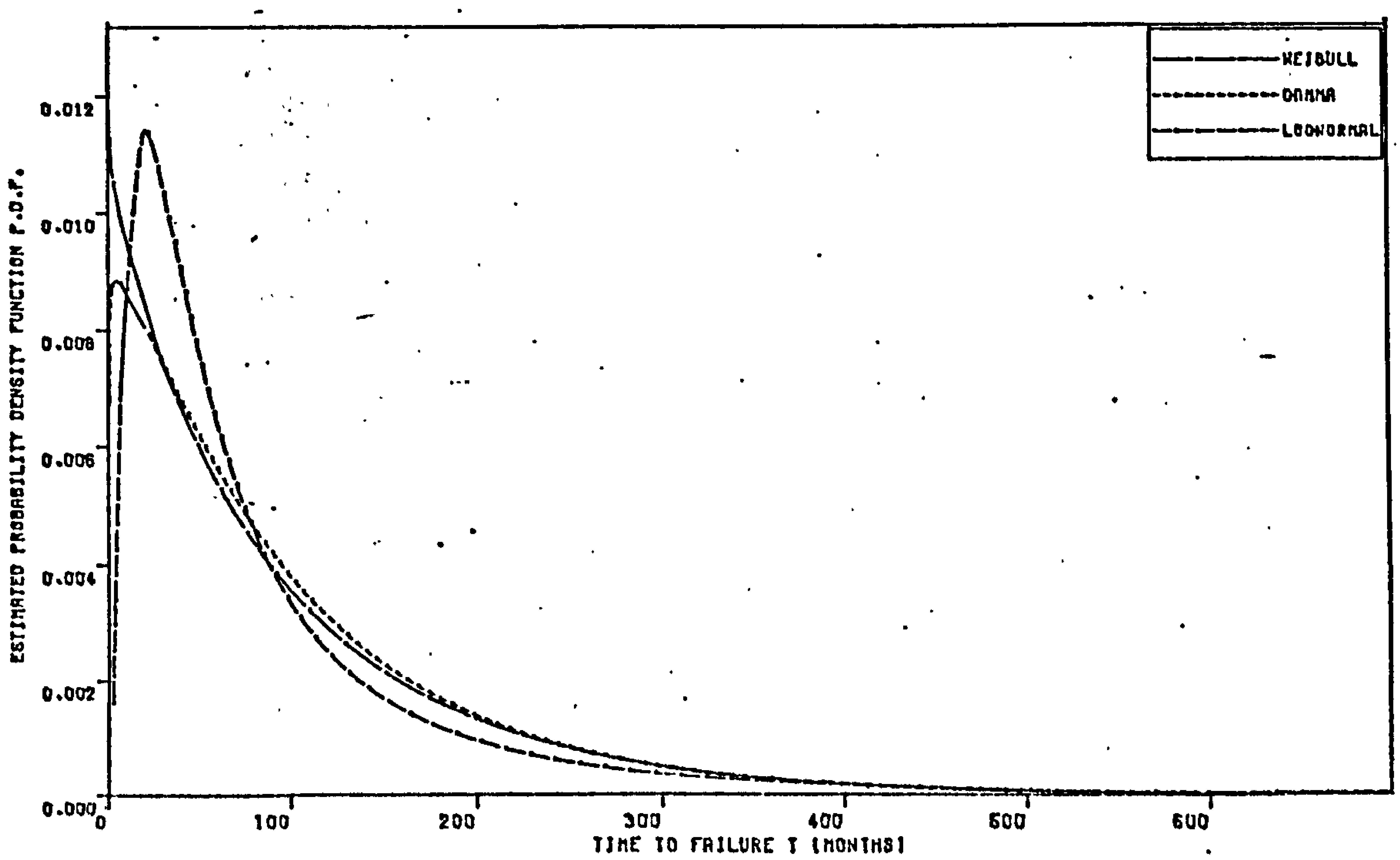


Fig. B.61

FIG . : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

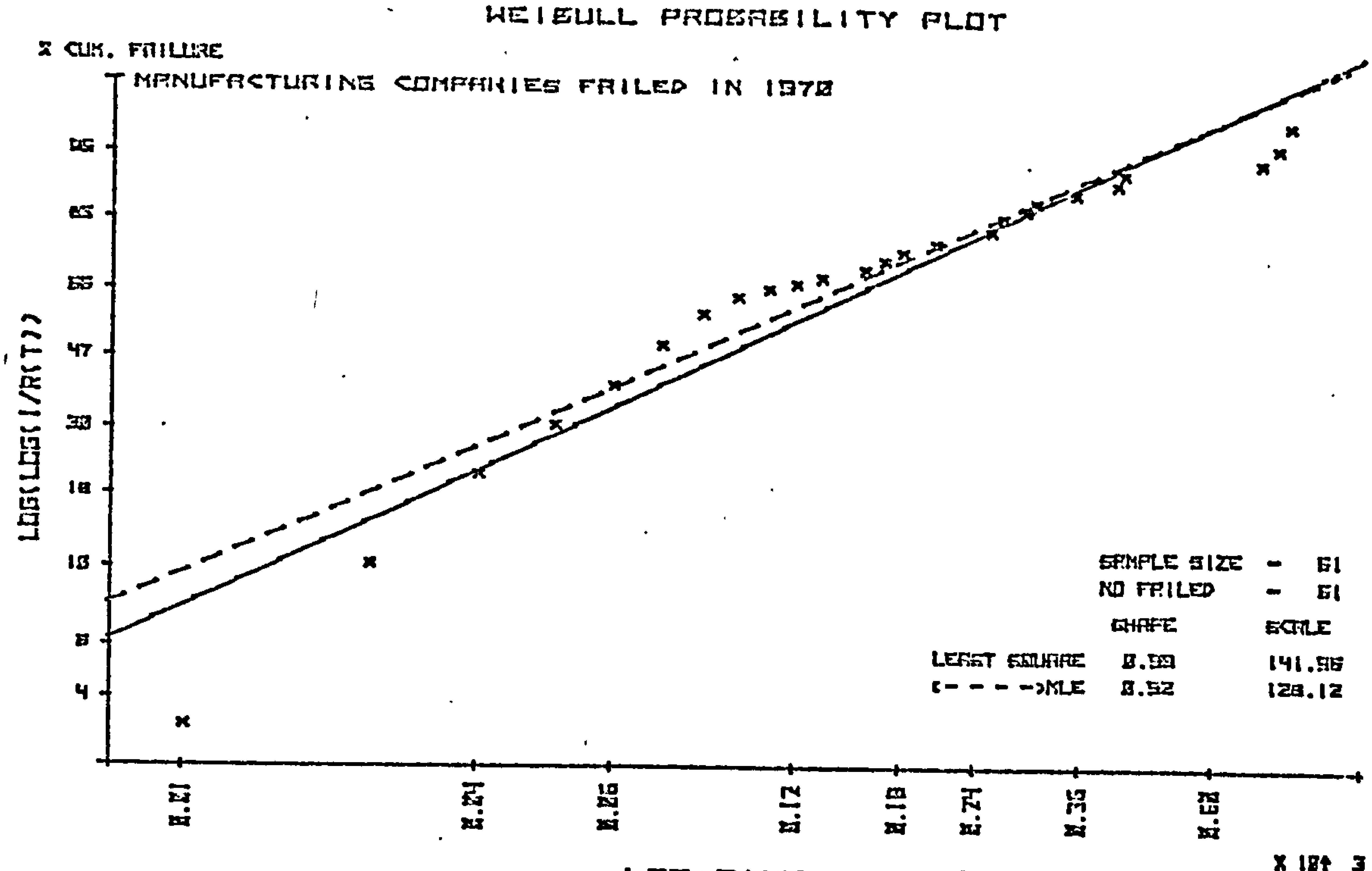


Fig. B.62

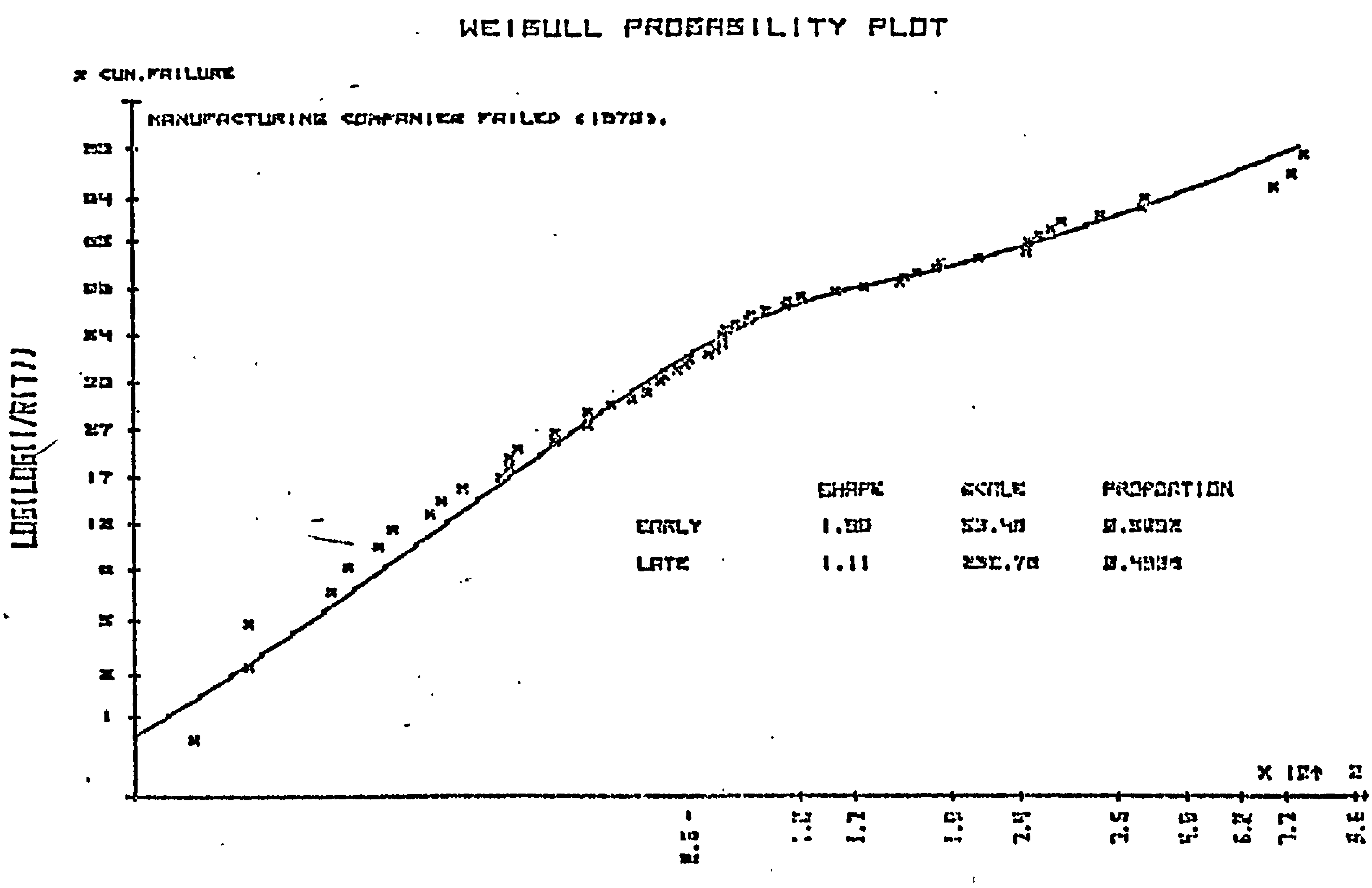


Fig. B.63

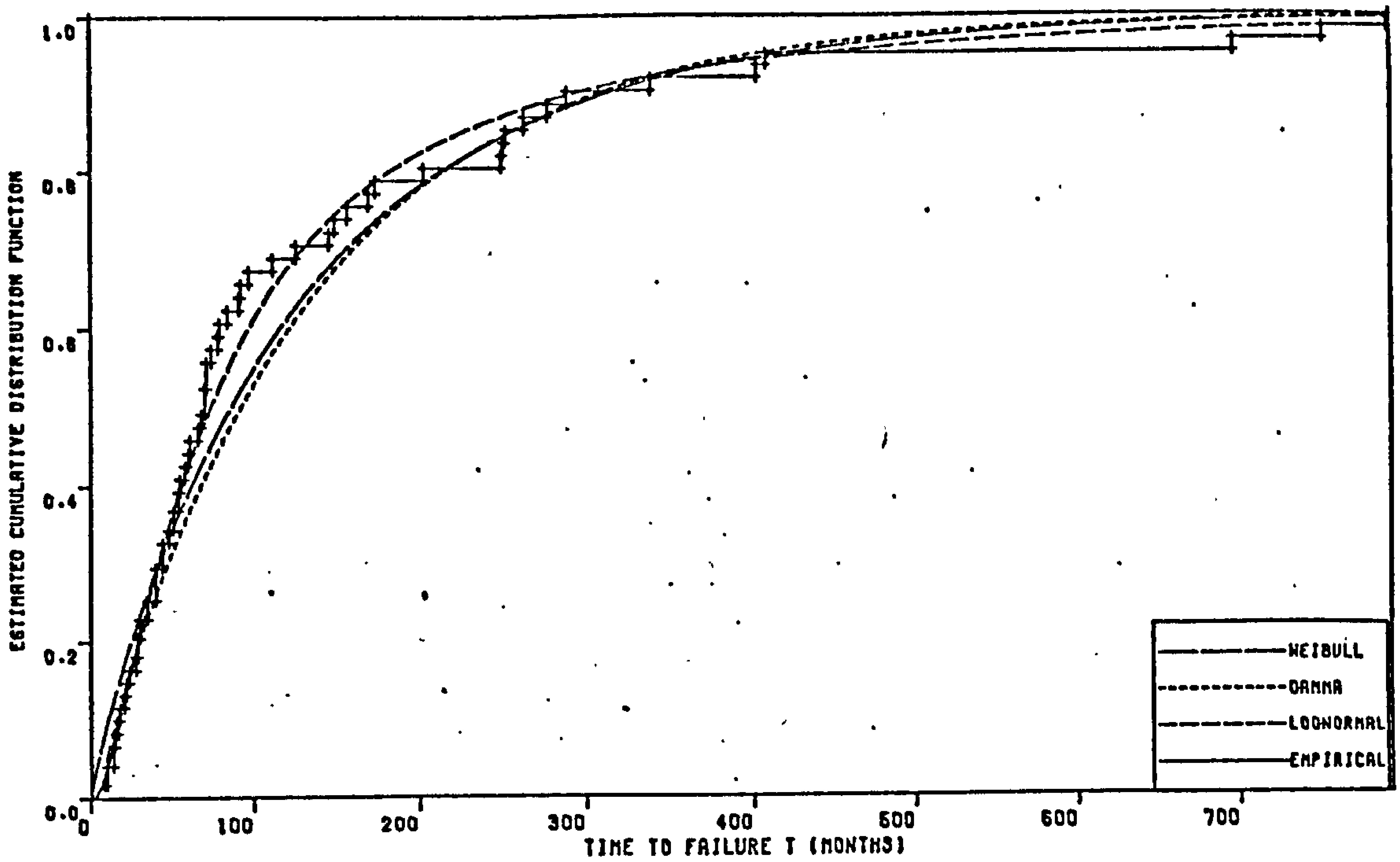


Fig. B.64 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

<u>MANUFACTURING COMPANIES FAILED IN 1970</u>

	SHAPE	SCALE
LOG-NORMAL	1.08	4.30
WEIBULL	0.92	128
GAMMA	0.61	220

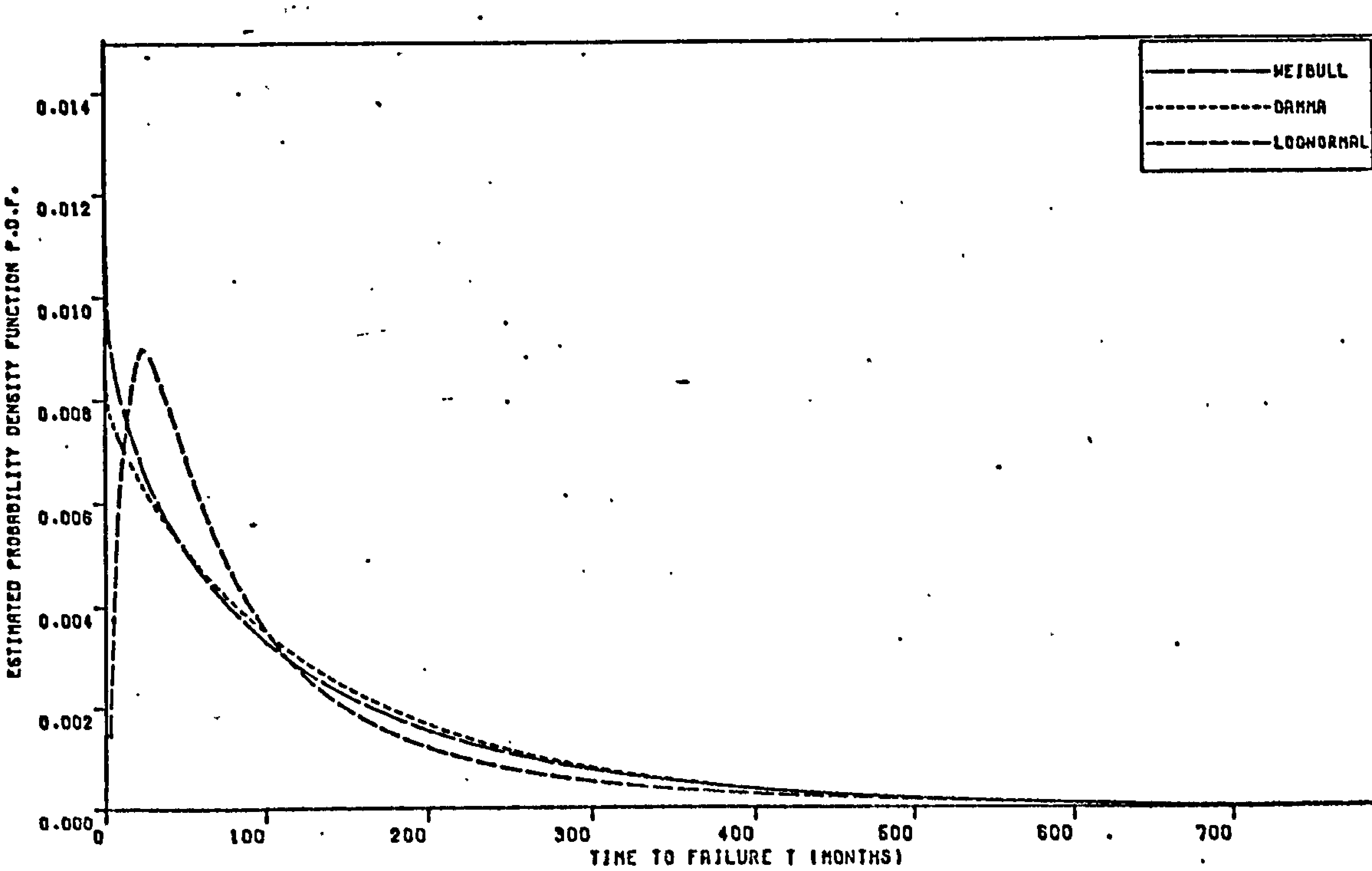


Fig. B.65 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

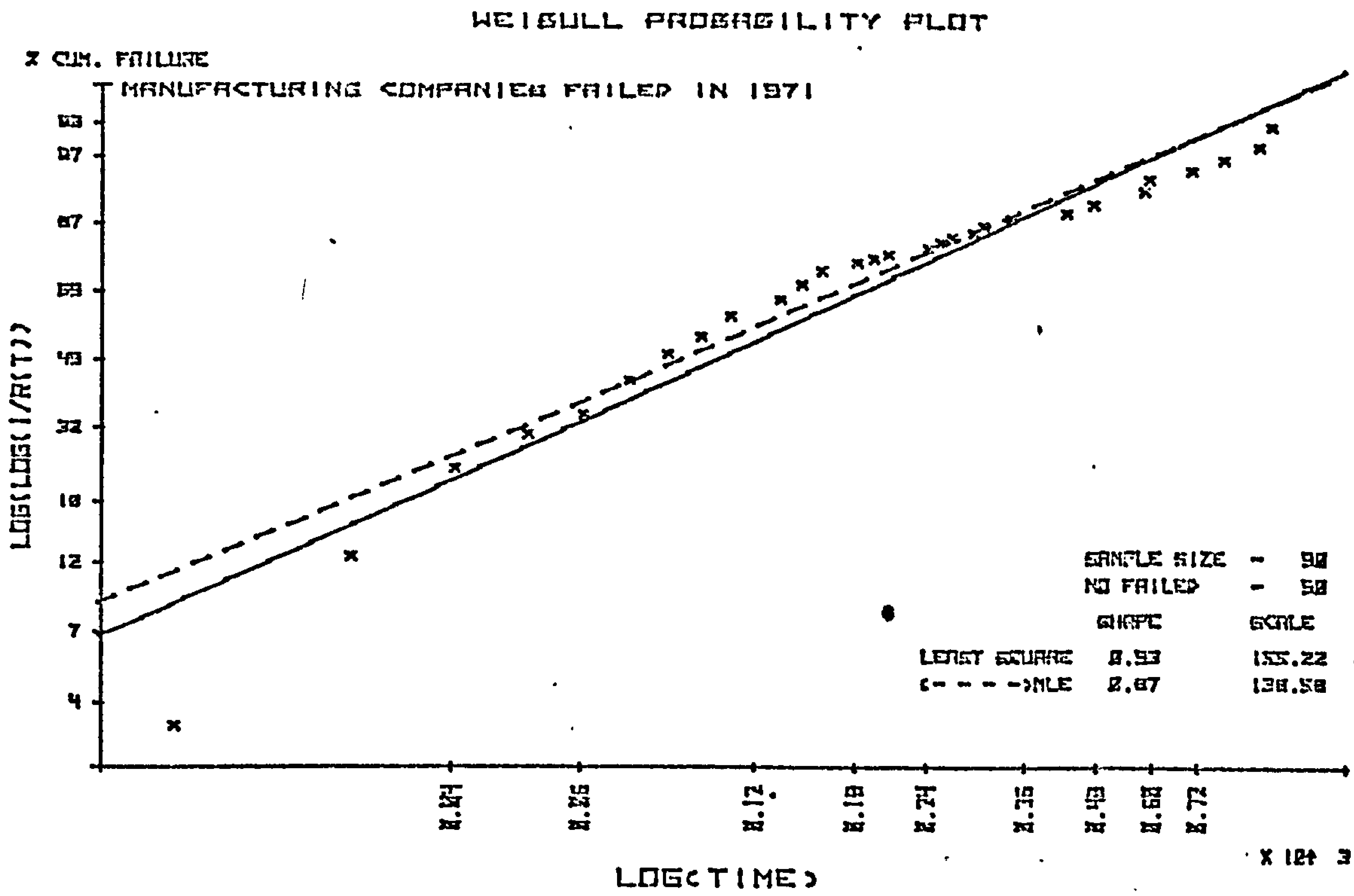


Fig. B.66

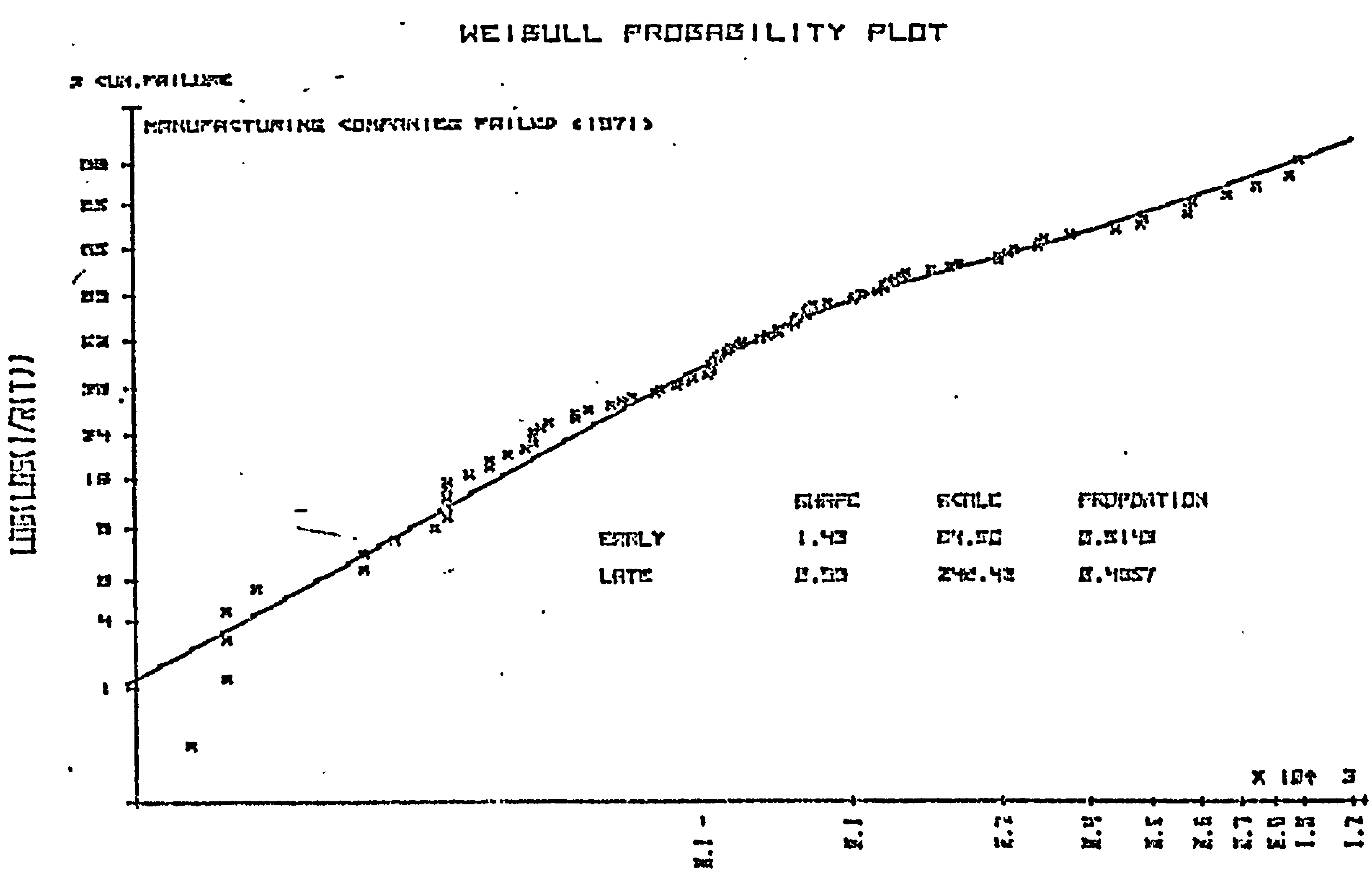


Fig. B.67

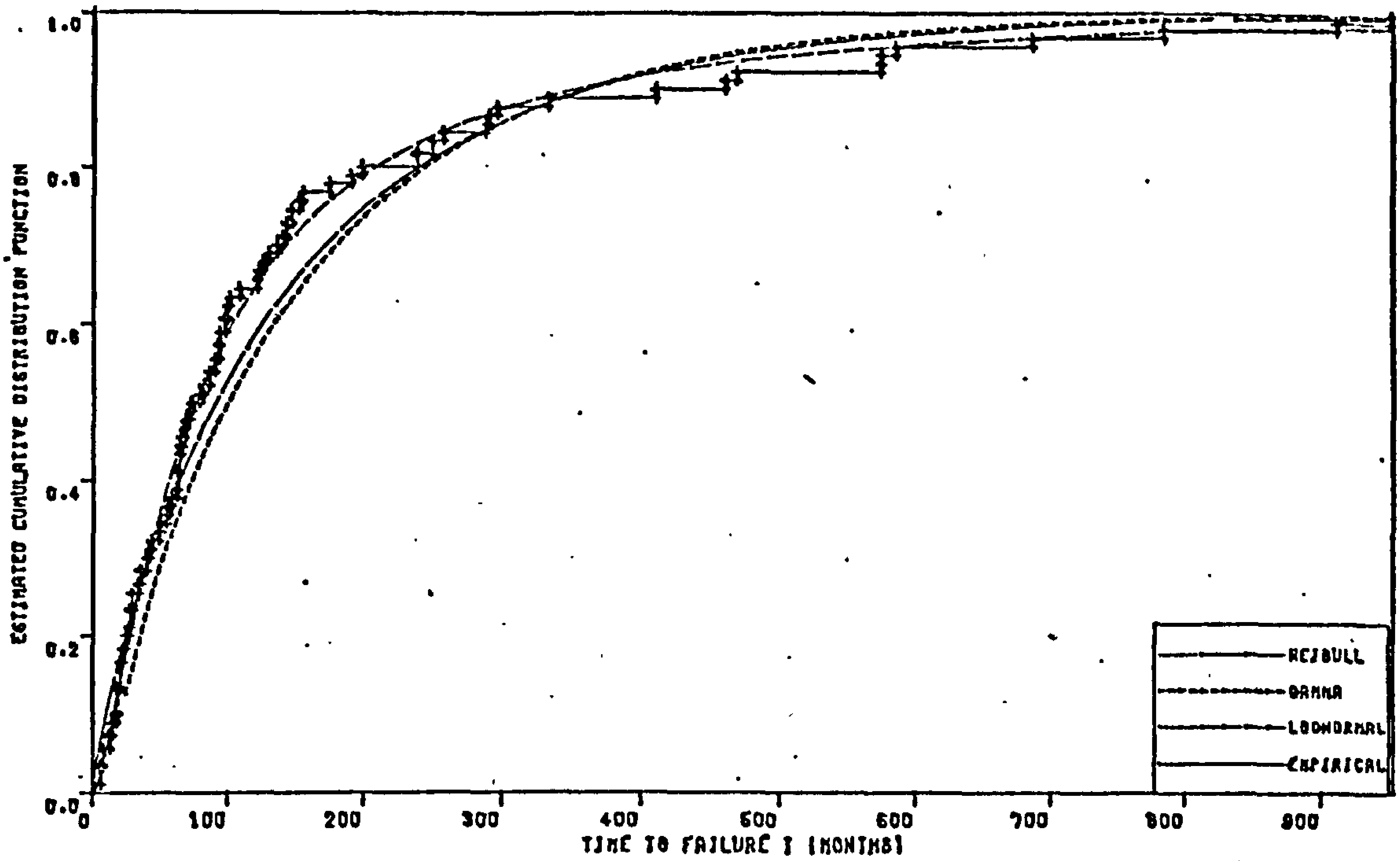


Fig. B.68 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1971

	SHAPE	SCALE
LOG-NORMAL	1.19	4.33
WEIBULL	0.86	139
GAMMA	0.57	262

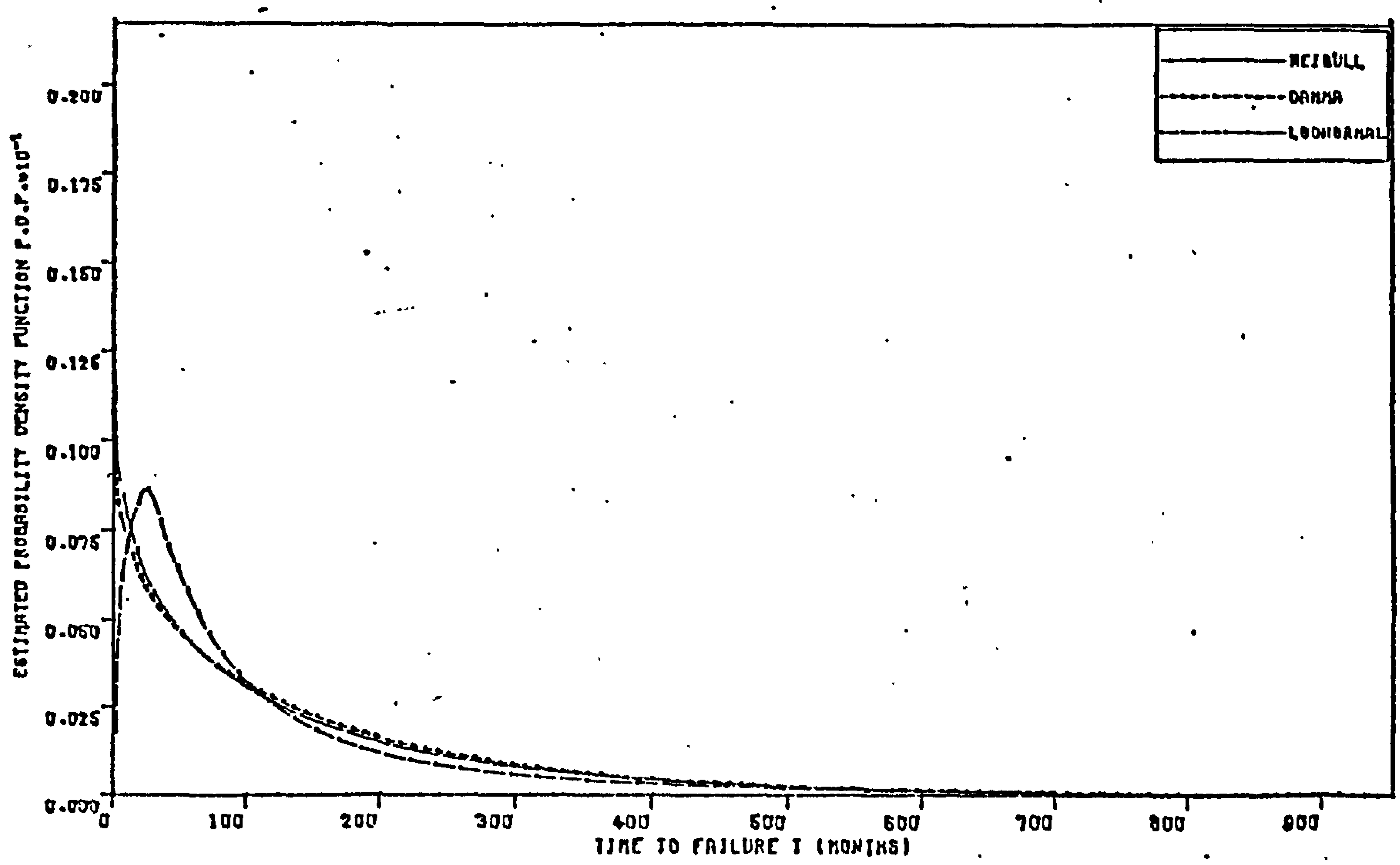


Fig. B.69 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

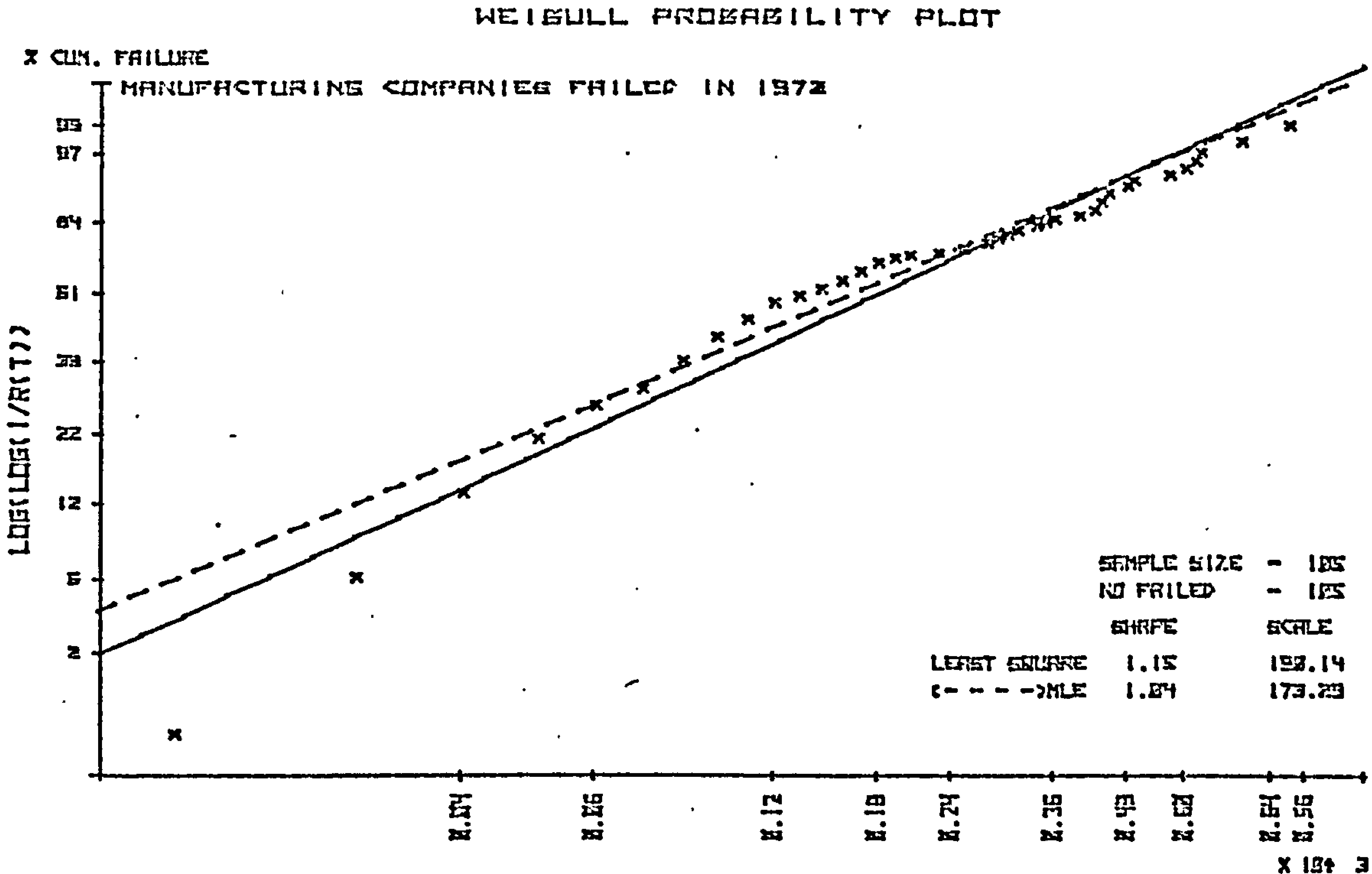


Fig. B.70

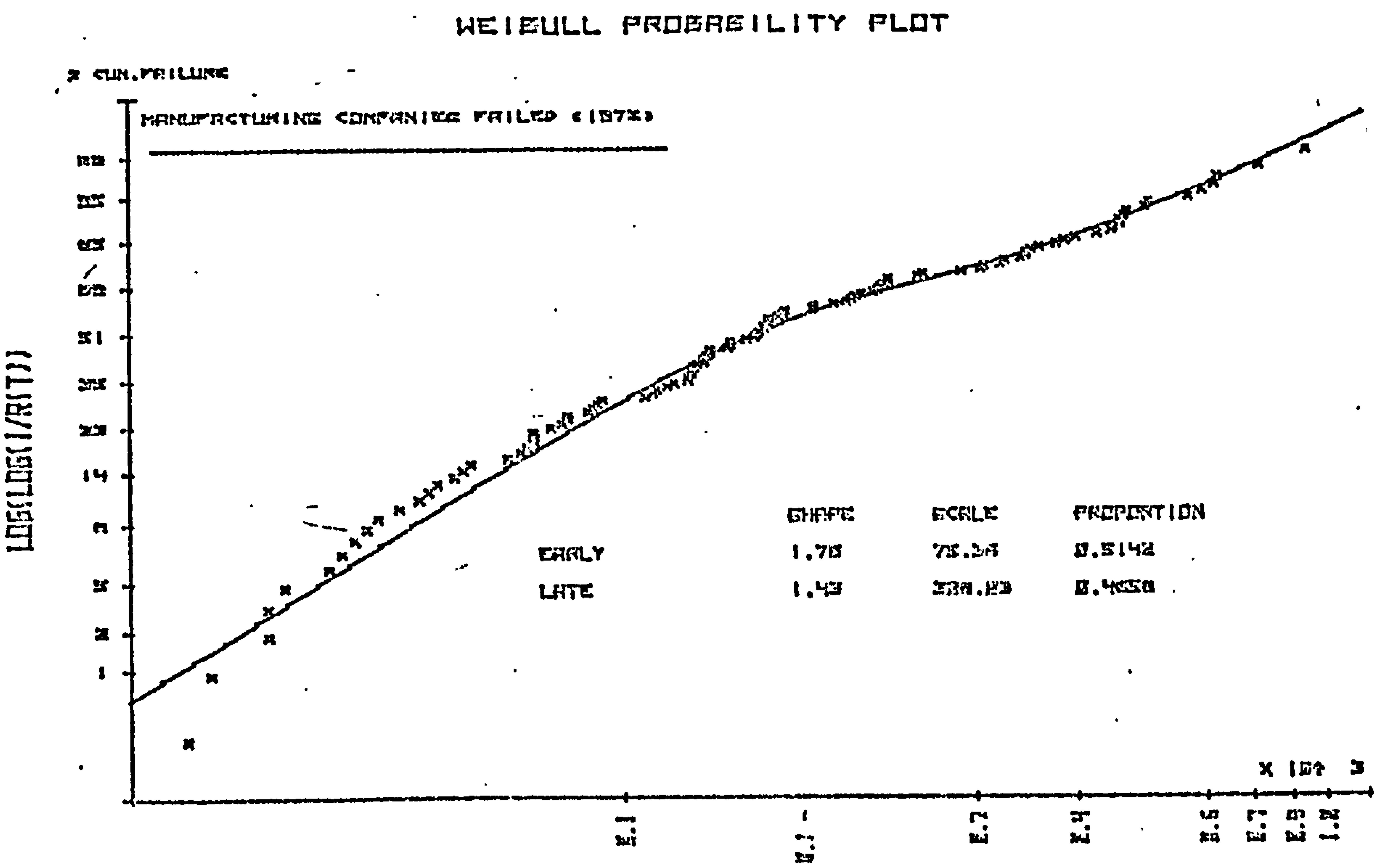


Fig. B.71

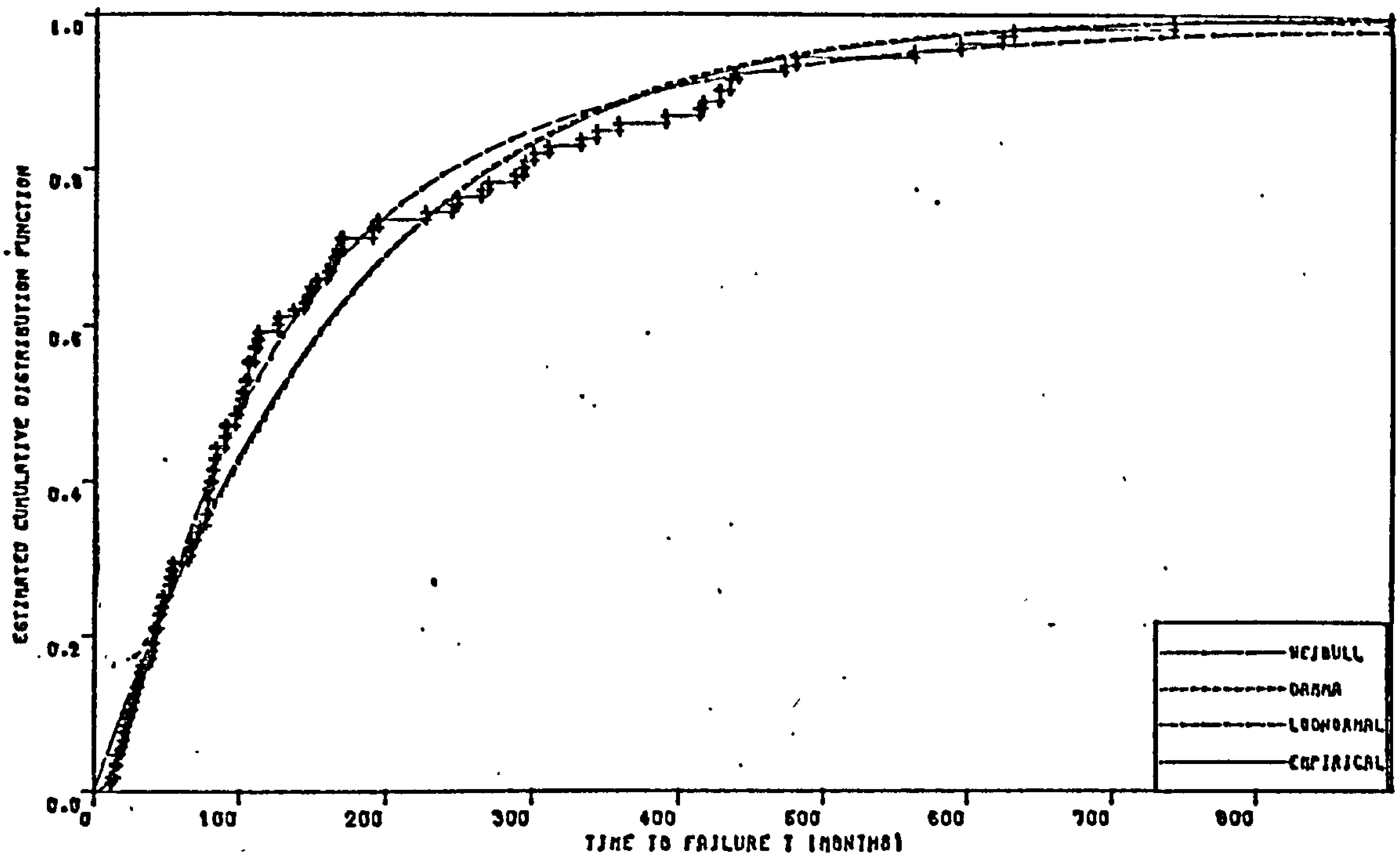


Fig. B.72 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1972

	SHAPE	SCALE
LOG-NORMAL	1.03	4.64
WEIBULL	1.03	173
GAMMA	0.93	184

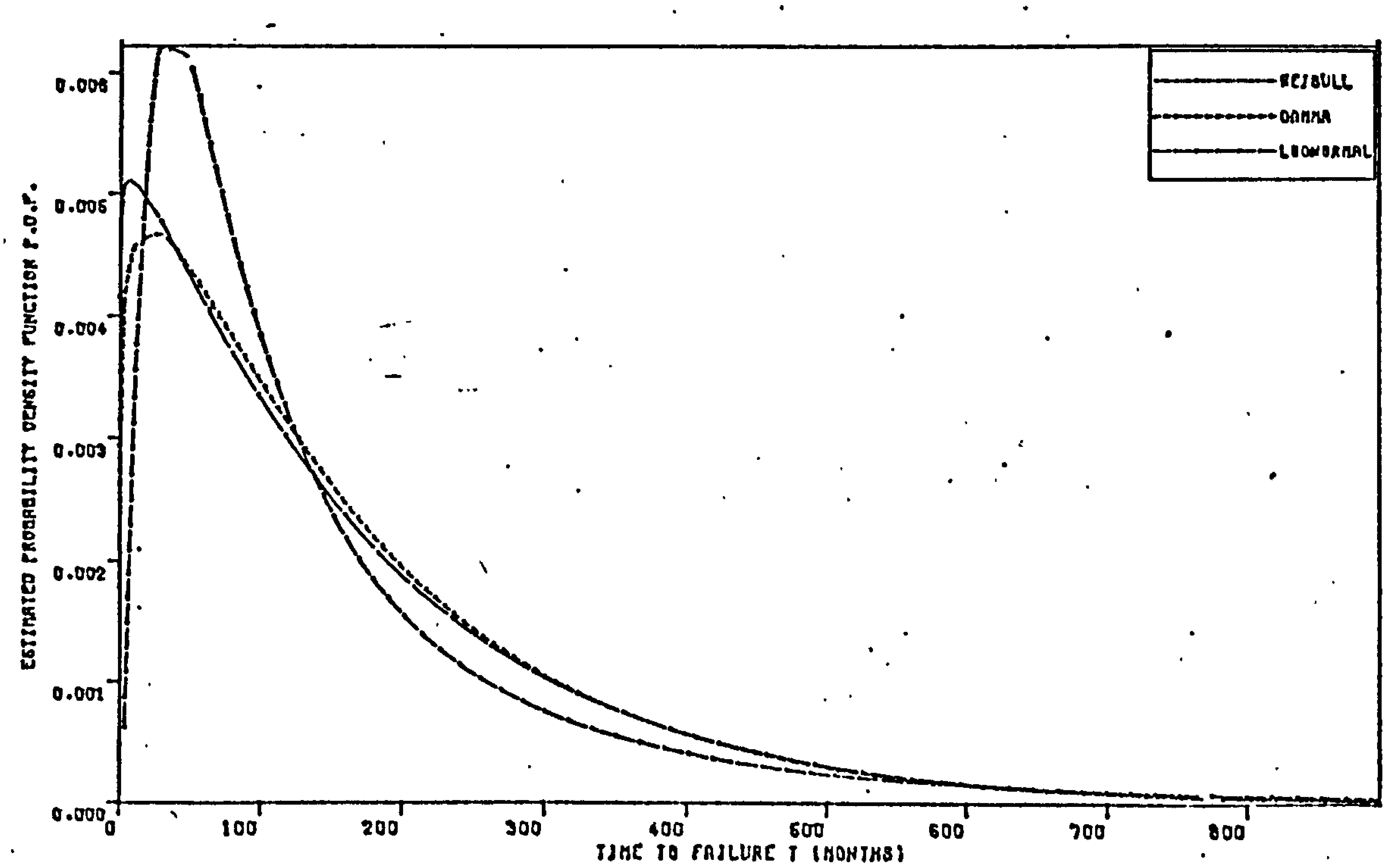


Fig. B.73 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

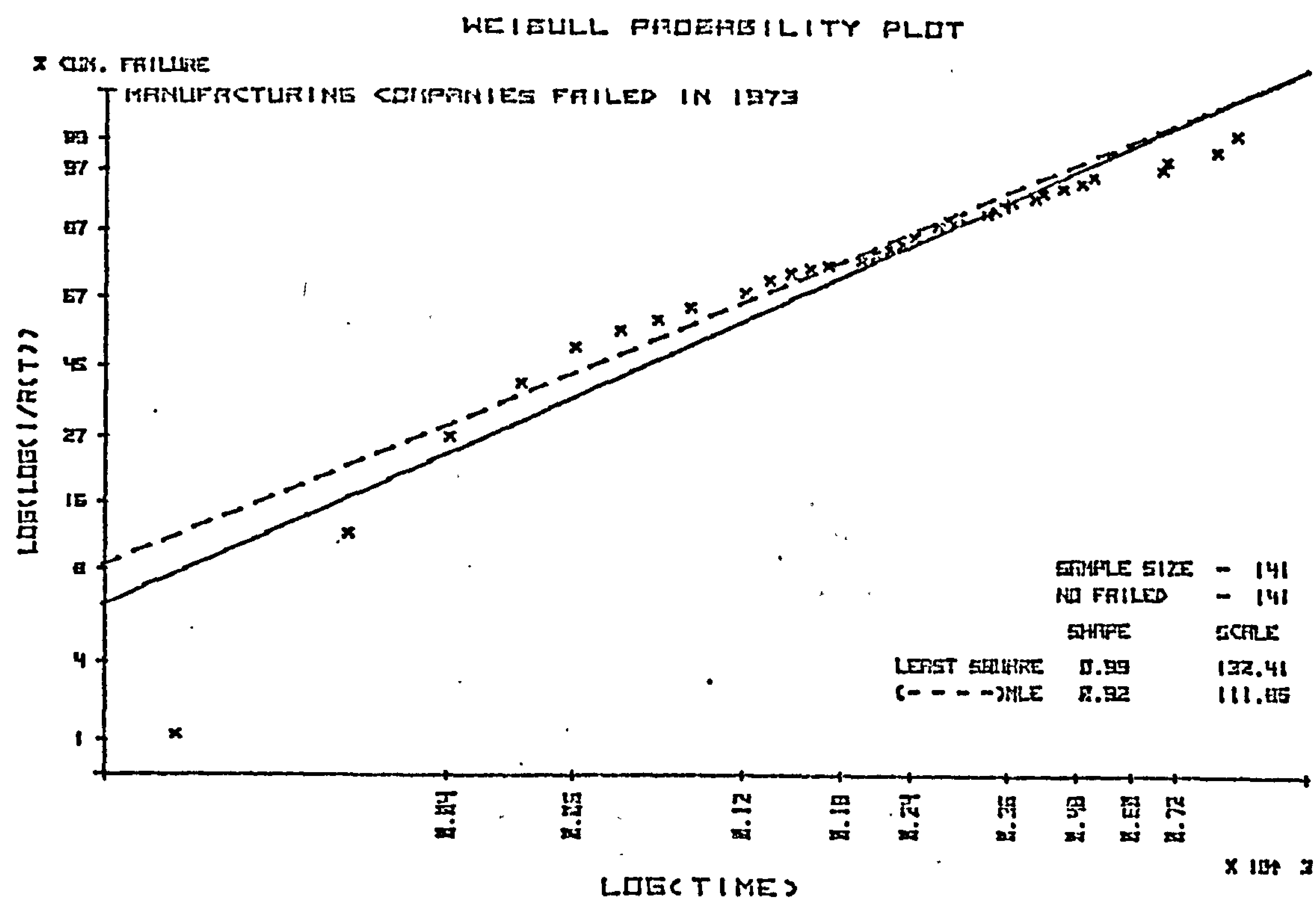


Fig. B.74

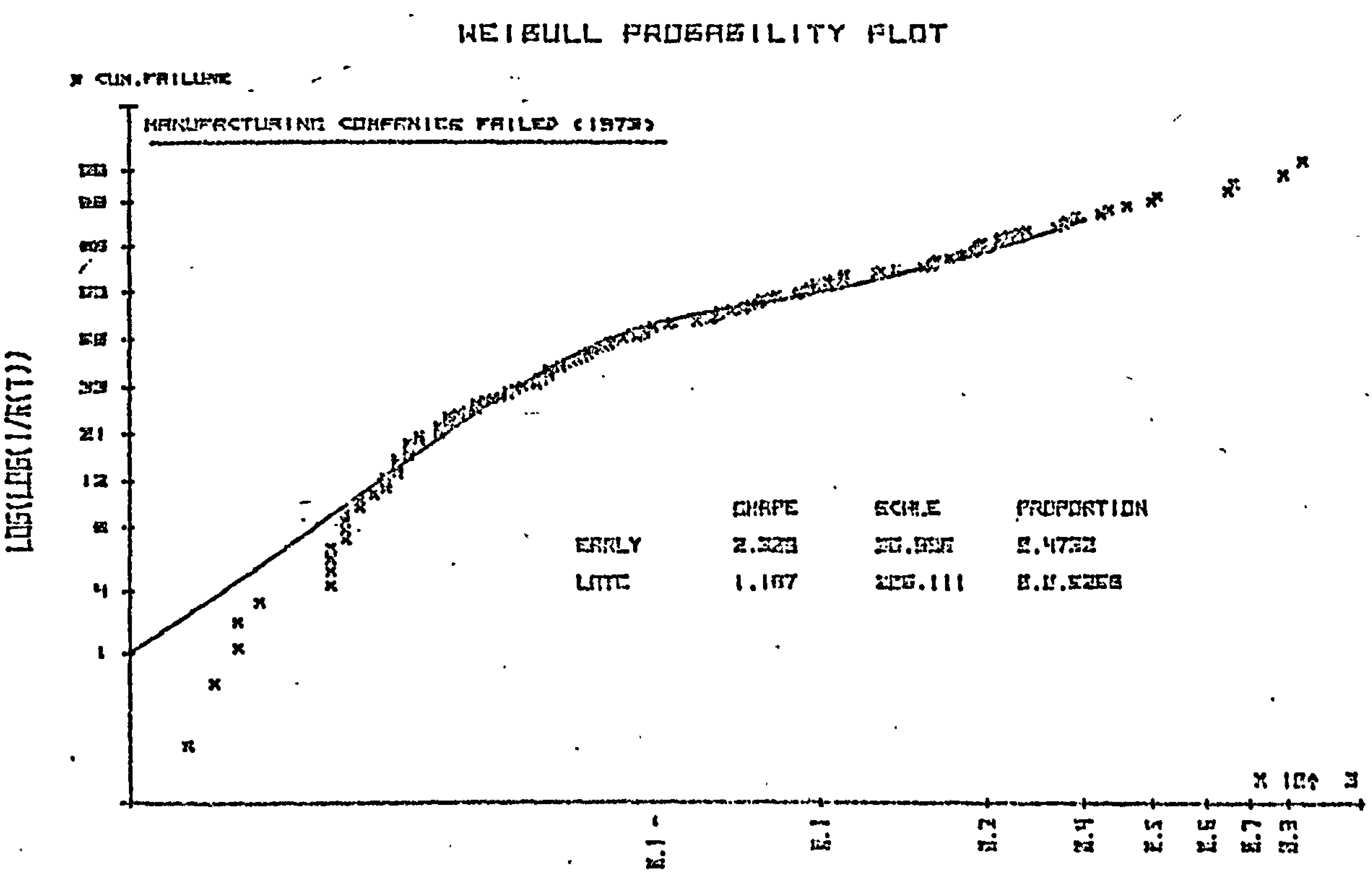


Fig. B.75

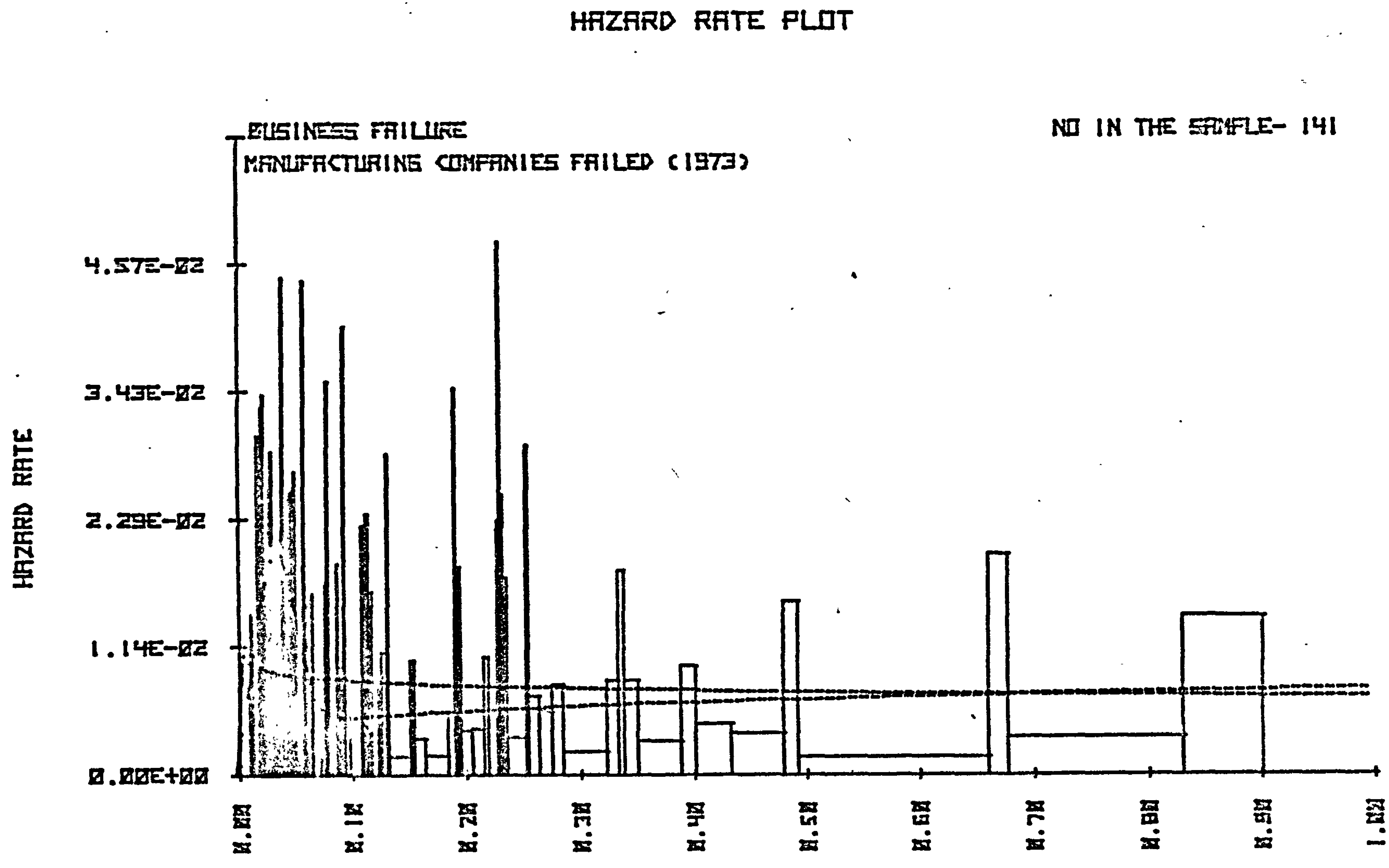

HAZARD RATE PLOT
BUSINESS FAILURE
MANUFACTURING COMPANIES FAILED (1973)
NO IN THE SAMPLE- 141
HAZARD RATE
4.57E-02
3.43E-02
2.29E-02
1.14E-02
0.00E+00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
FAILURE TIME (MONTH)
X 10^ 3

Fig. B.76

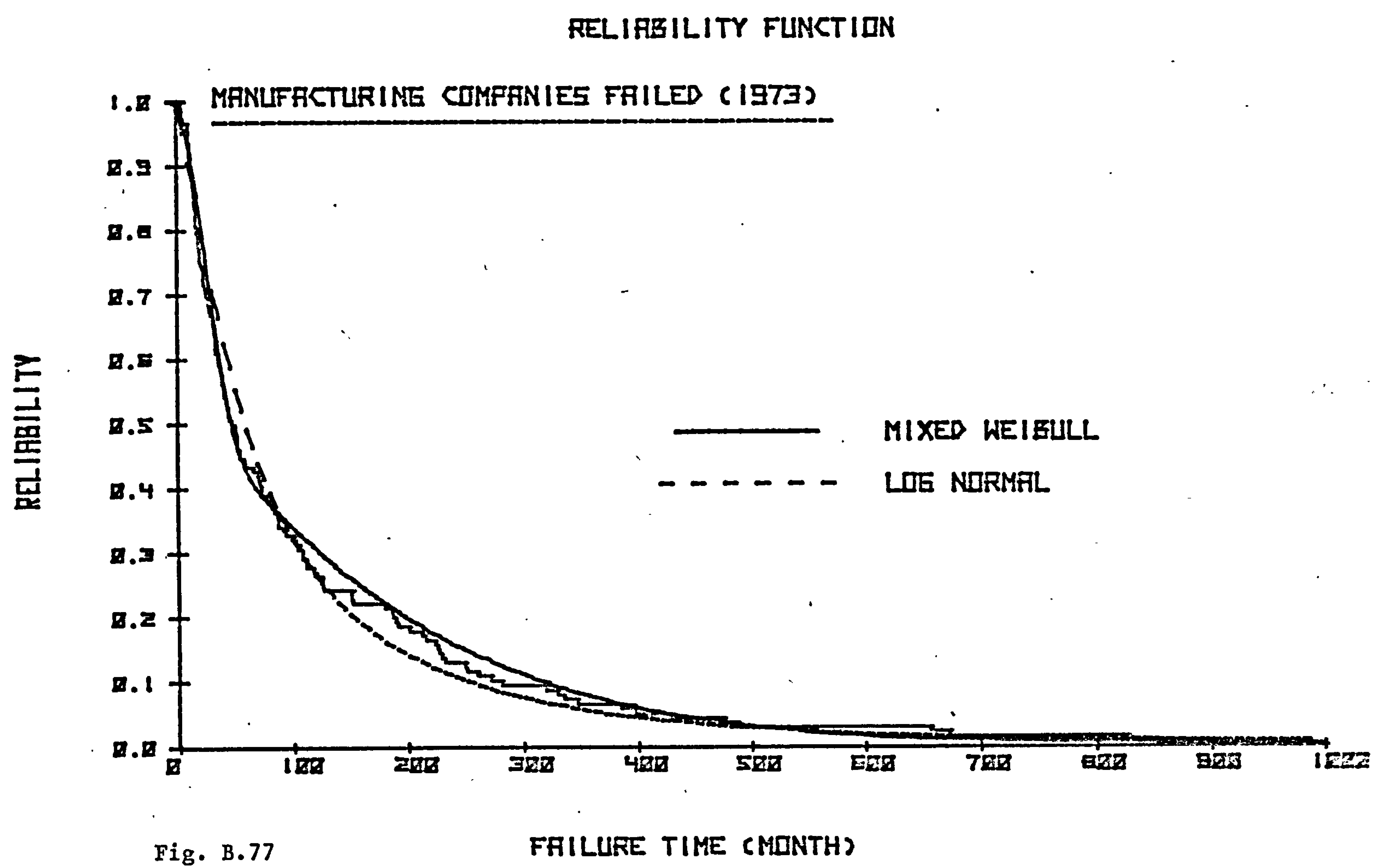

RELIABILITY FUNCTION
MANUFACTURING COMPANIES FAILED (1973)
RELIABILITY
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
100
200
300
400
500
600
700
800
900
1000
MIXED WEIBULL
LOG NORMAL
FAILURE TIME (MONTH)

Fig. B.77

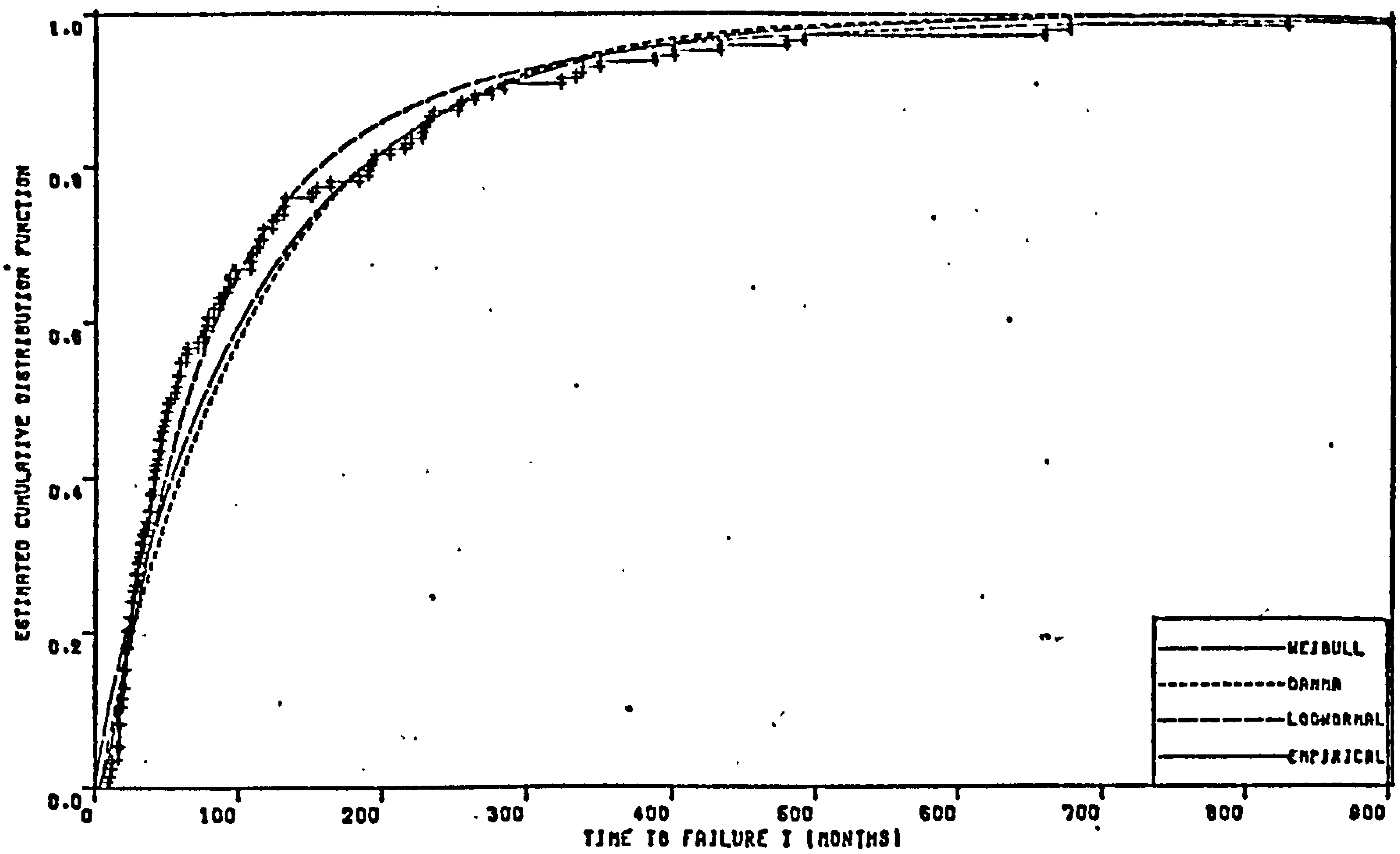


Fig. B.78

FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1973

	SHAPE	SCALE
LOG-NORMAL	1.06	4.17
WEIBULL	0.92	112
GAMMA	0.58	201

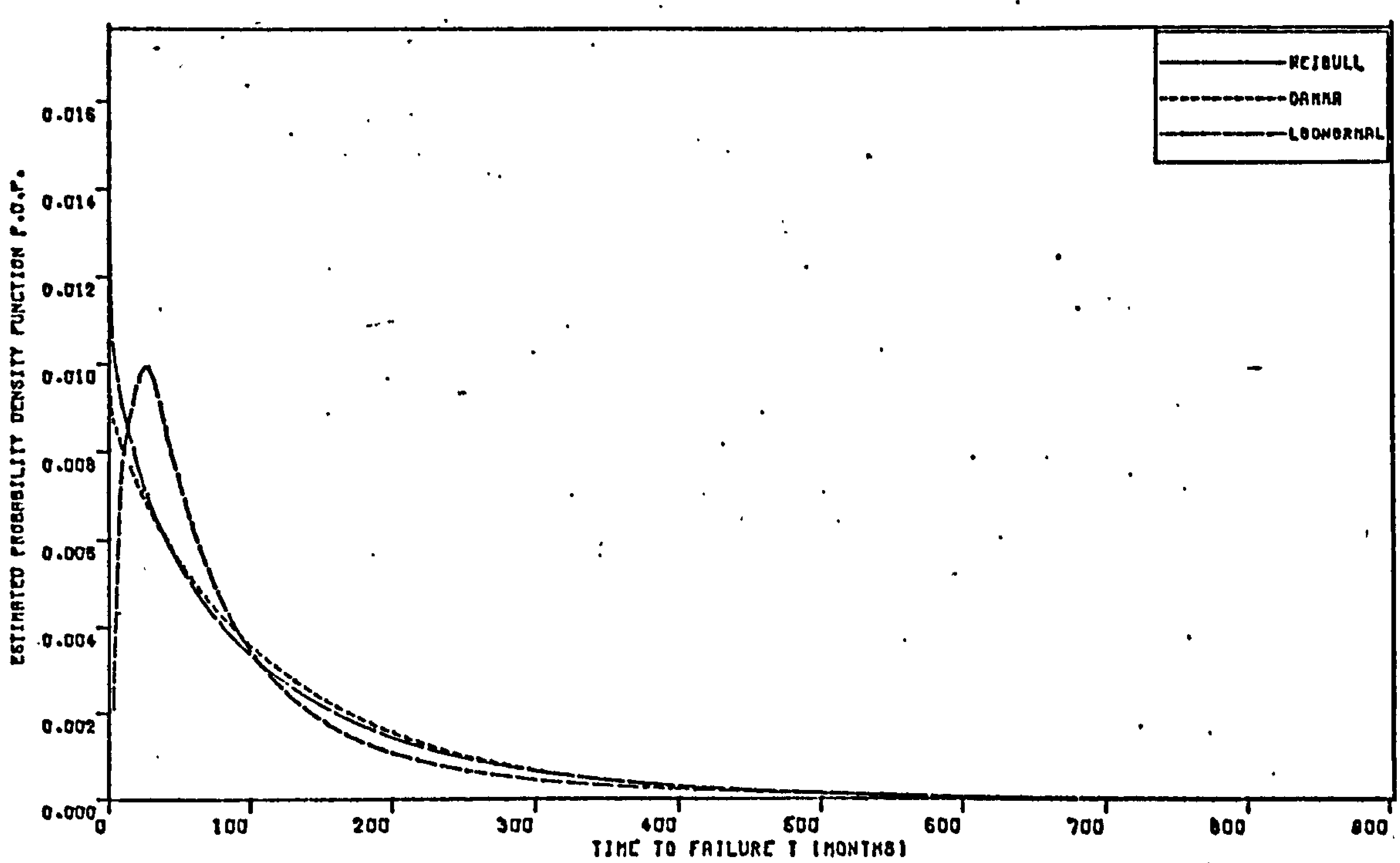


Fig. B.79

FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

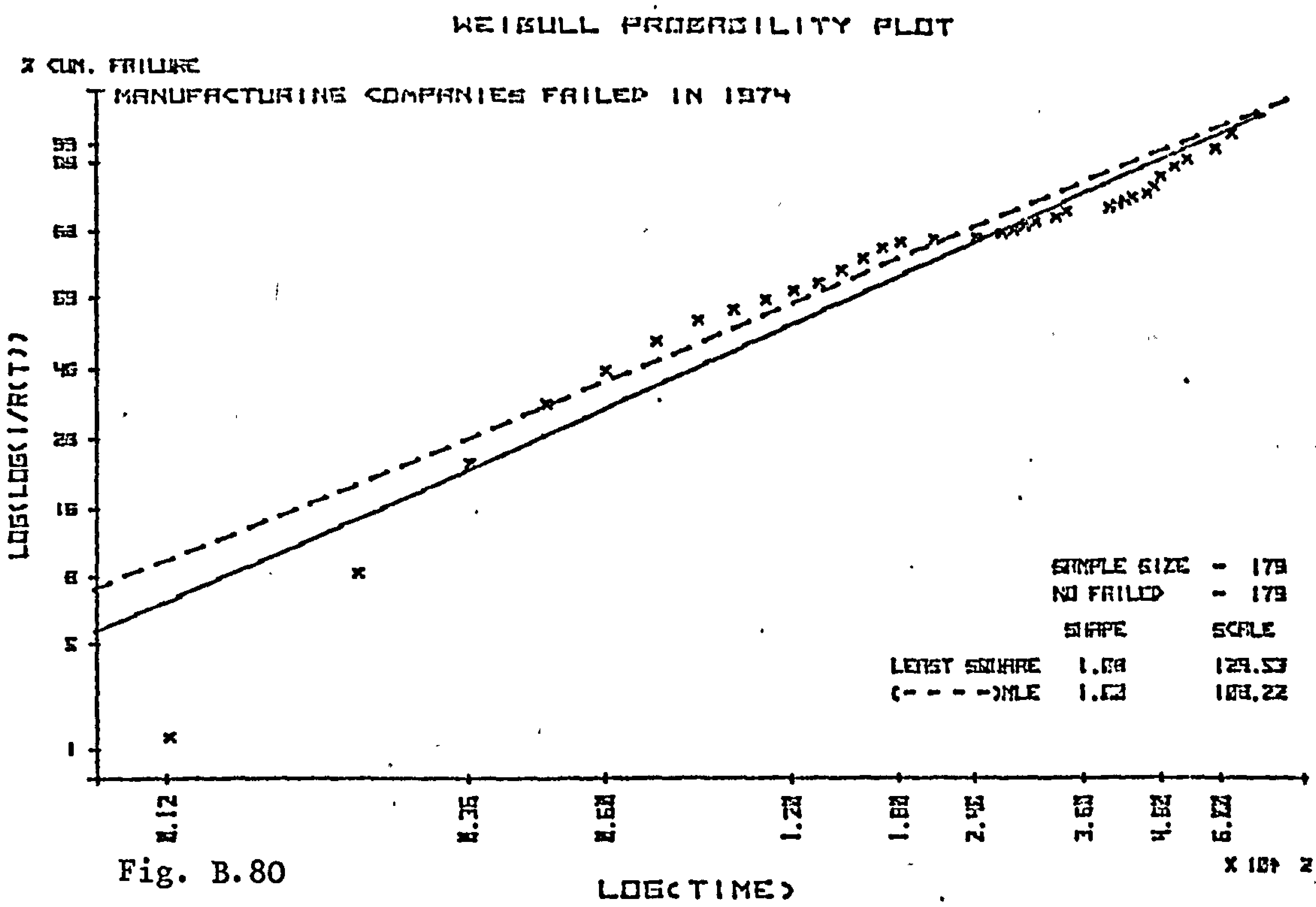


Fig. B.80

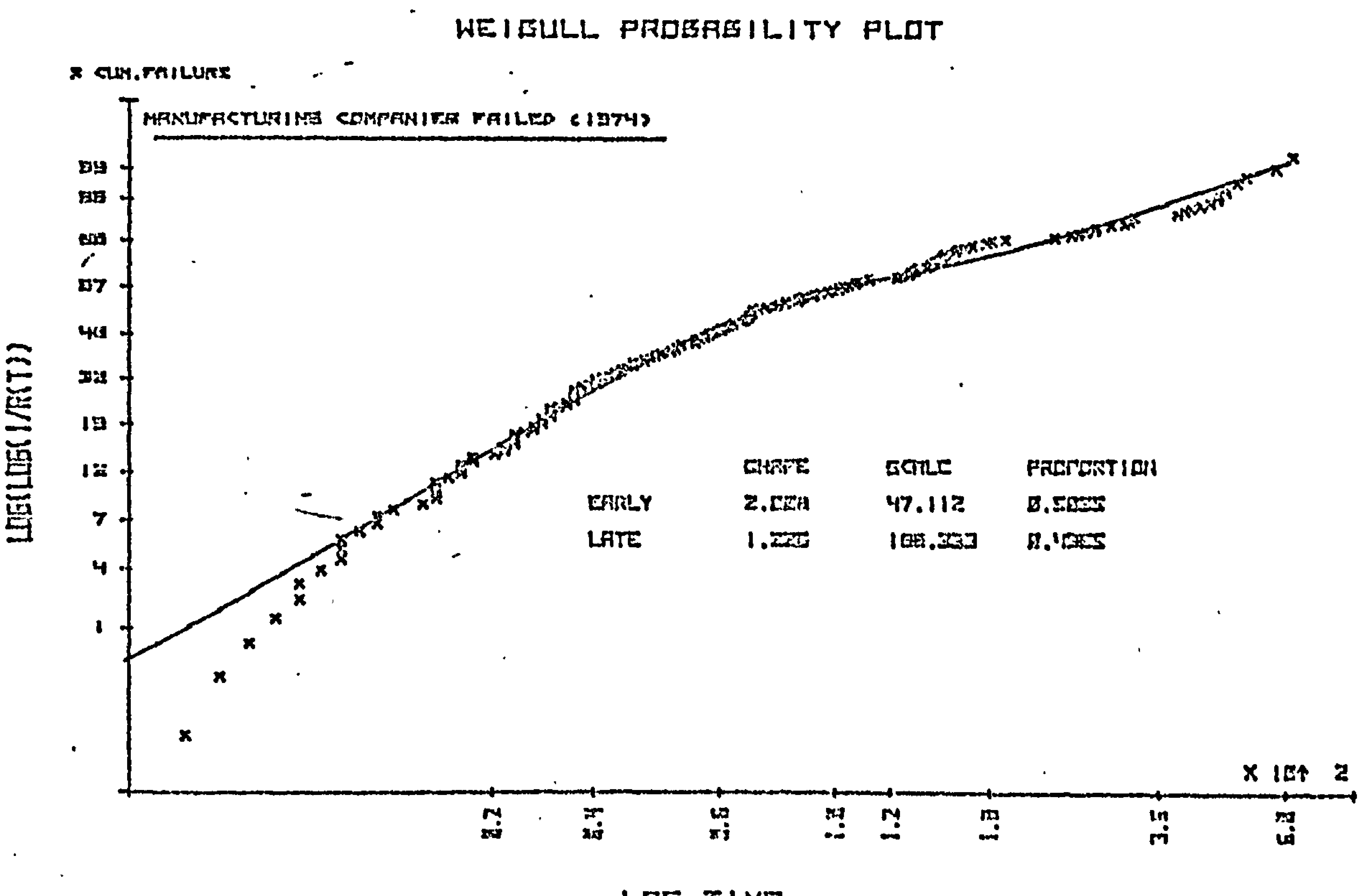


Fig. B.81

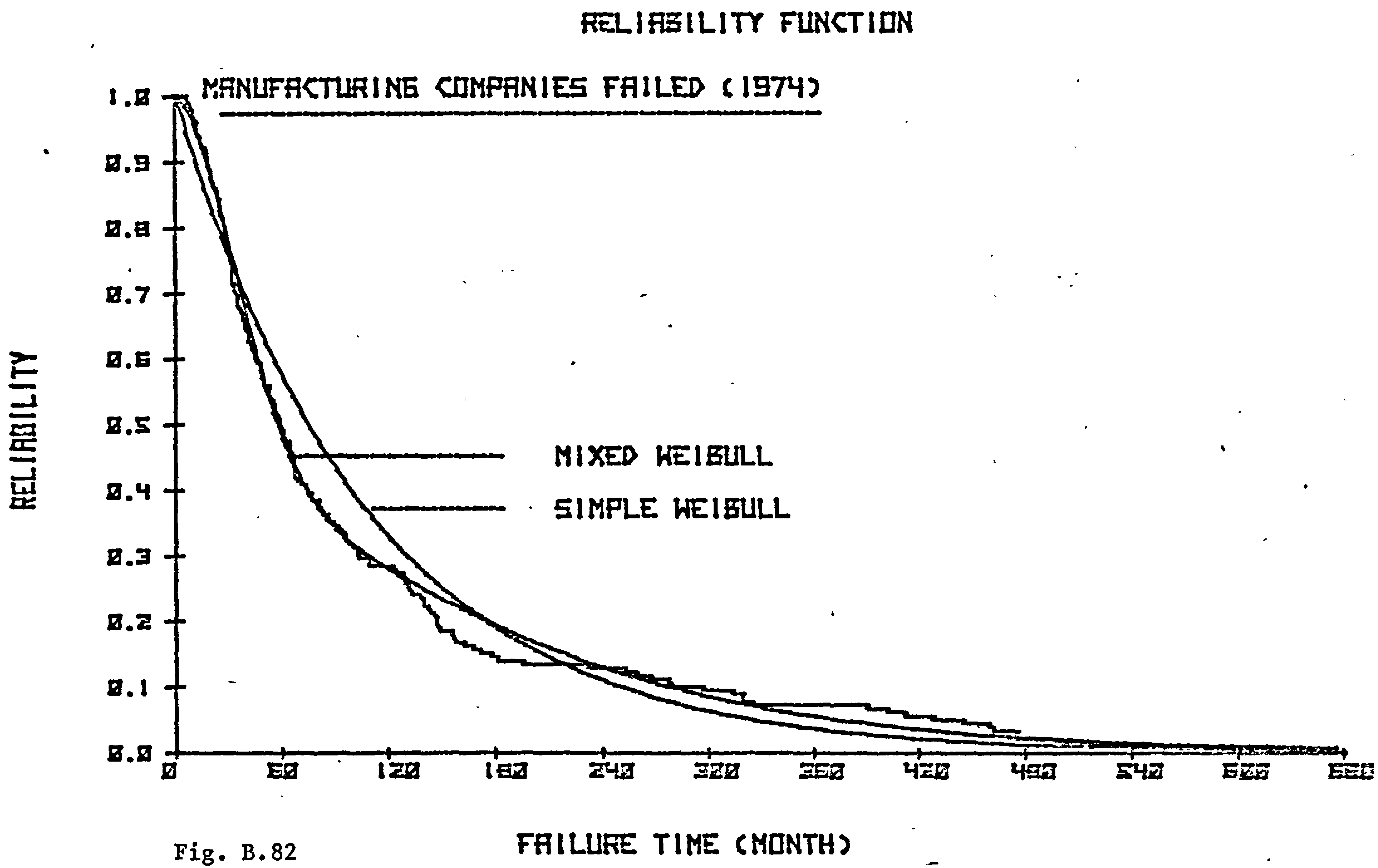

RELIABILITY FUNCTION
MANUFACTURING COMPANIES FAILED (1974)
RELIABILITY
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
MIXED WEIBULL
SIMPLE WEIBULL
0
60
120
180
240
300
360
420
480
540
600
660
FAILURE TIME (MONTH)

Fig. B.82

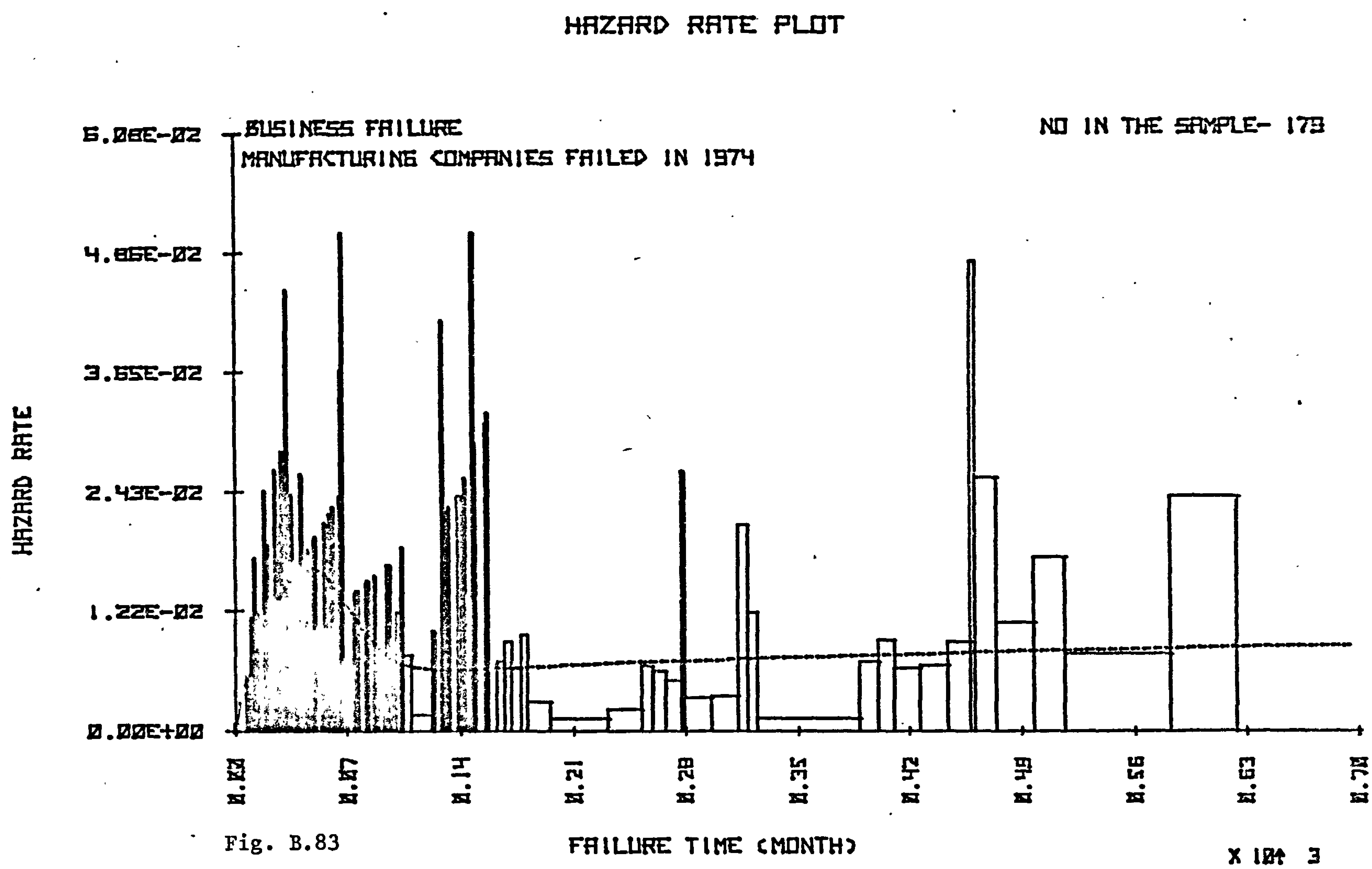

HAZARD RATE PLOT
BUSINESS FAILURE
MANUFACTURING COMPANIES FAILED IN 1974
NO IN THE SAMPLE- 178
HAZARD RATE
6.08E-02
4.86E-02
3.65E-02
2.43E-02
1.22E-02
0.00E+00
0.00
0.07
0.14
0.21
0.28
0.35
0.42
0.49
0.56
0.63
0.70
FAILURE TIME (MONTH)
X 10↑ 3

Fig. B.83

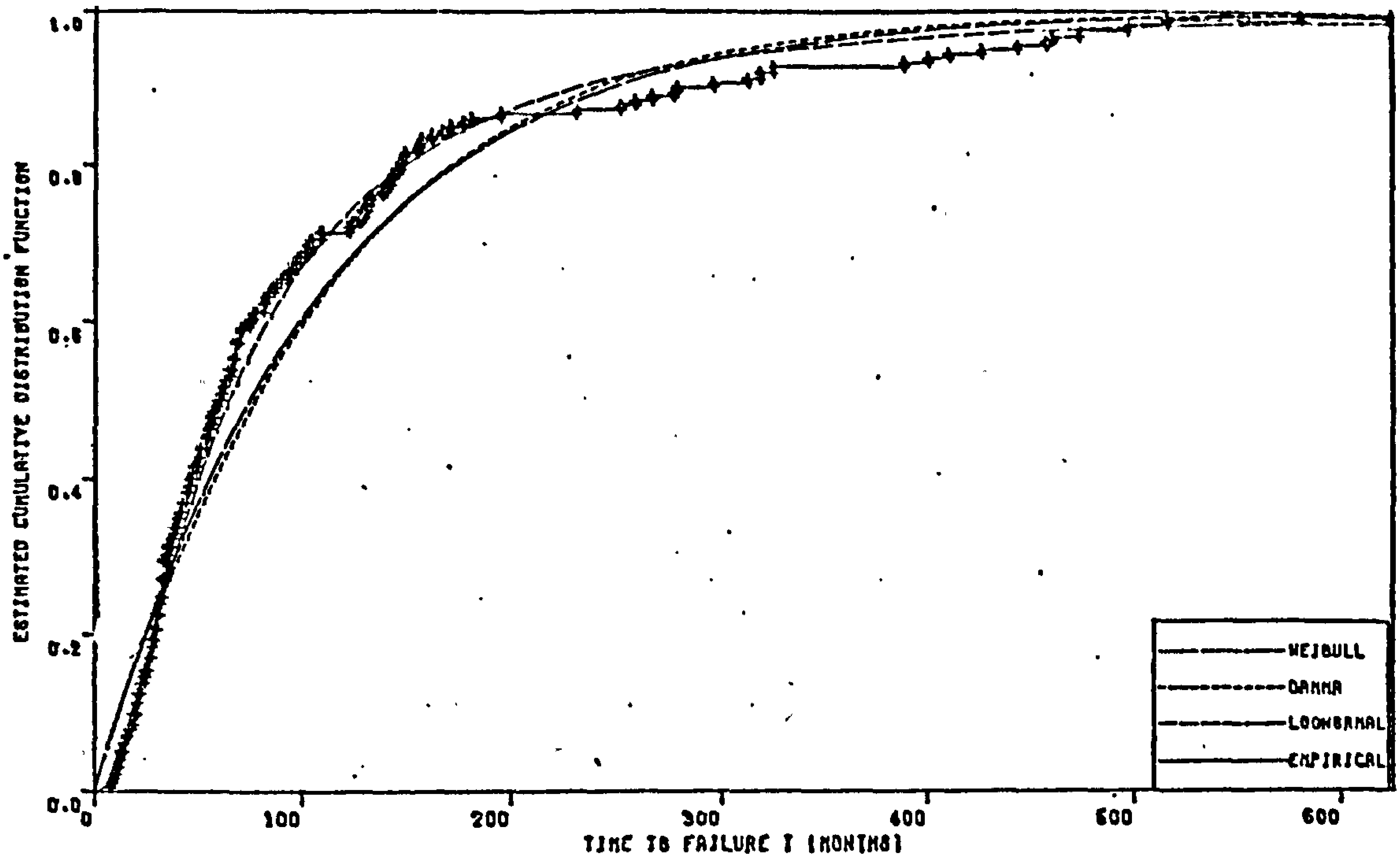


Fig. B.84 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1974

	SHAPE	SCALE
LOG-NORMAL	0.99	4.17
WEIBULL	1.00	108
GAMMA	0.75	145

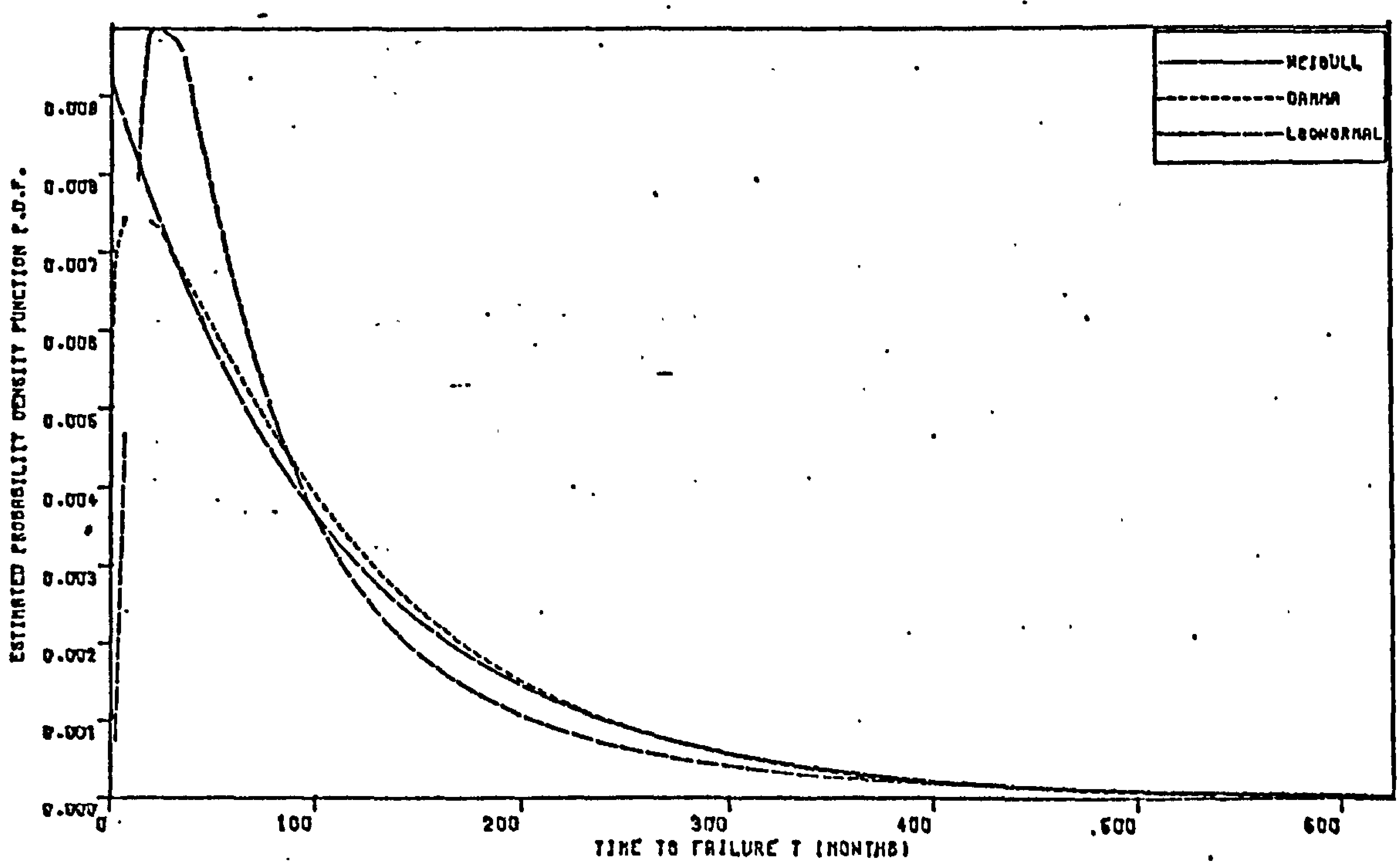


Fig. B.85 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

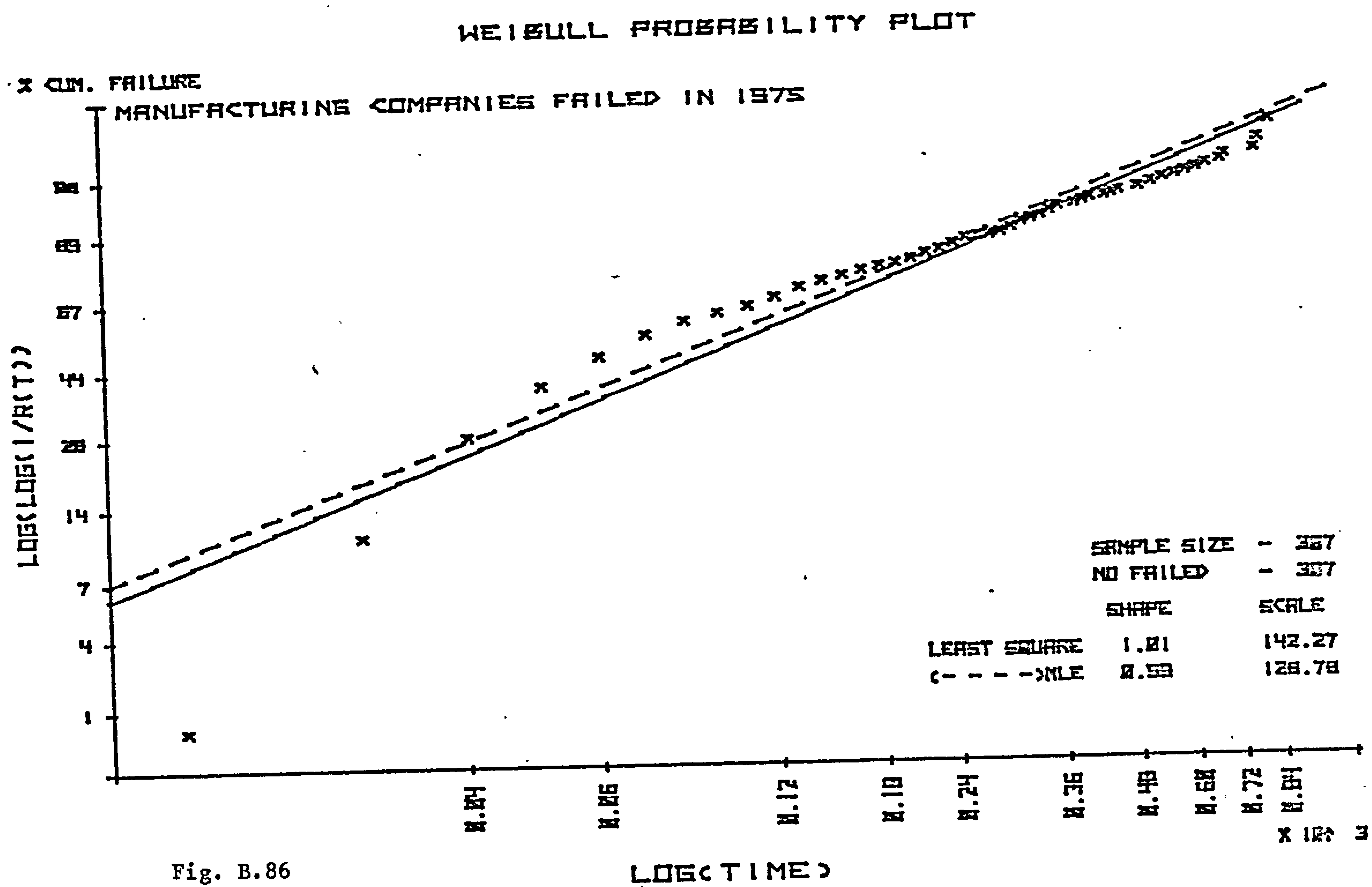

WEIBULL PROBABILITY PLOT
x CUM. FAILURE
MANUFACTURING COMPANIES FAILED IN 1975
LOG(LOG(1/R(T))
1
4
7
14
28
44
57
0.04
0.06
0.12
0.18
0.24
0.36
0.48
0.60
0.72
0.84
X 10^ 3
LOG(TIME)
SAMPLE SIZE - 307
NO FAILED - 307
SHAPE SCALE
LEAST SQUARE 1.01 142.27
(- - - -)MLE 0.53 128.78

Fig. B.86

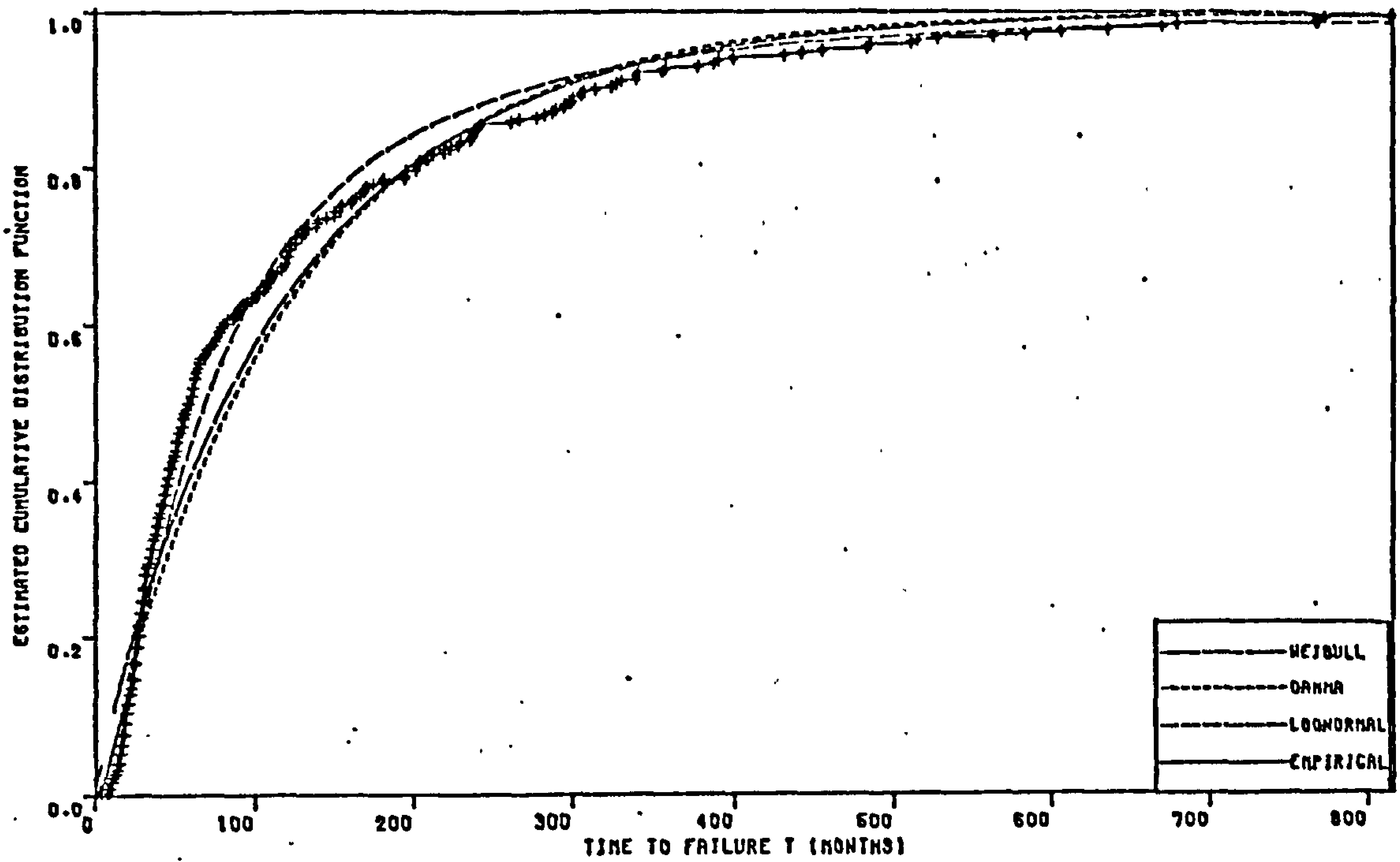


Fig. B.87 FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1975

	SHAPE	SCALE
LOG-NORMAL	1.07	4.23
WEIBULL	0.93	119
GAMMA	0.66	185

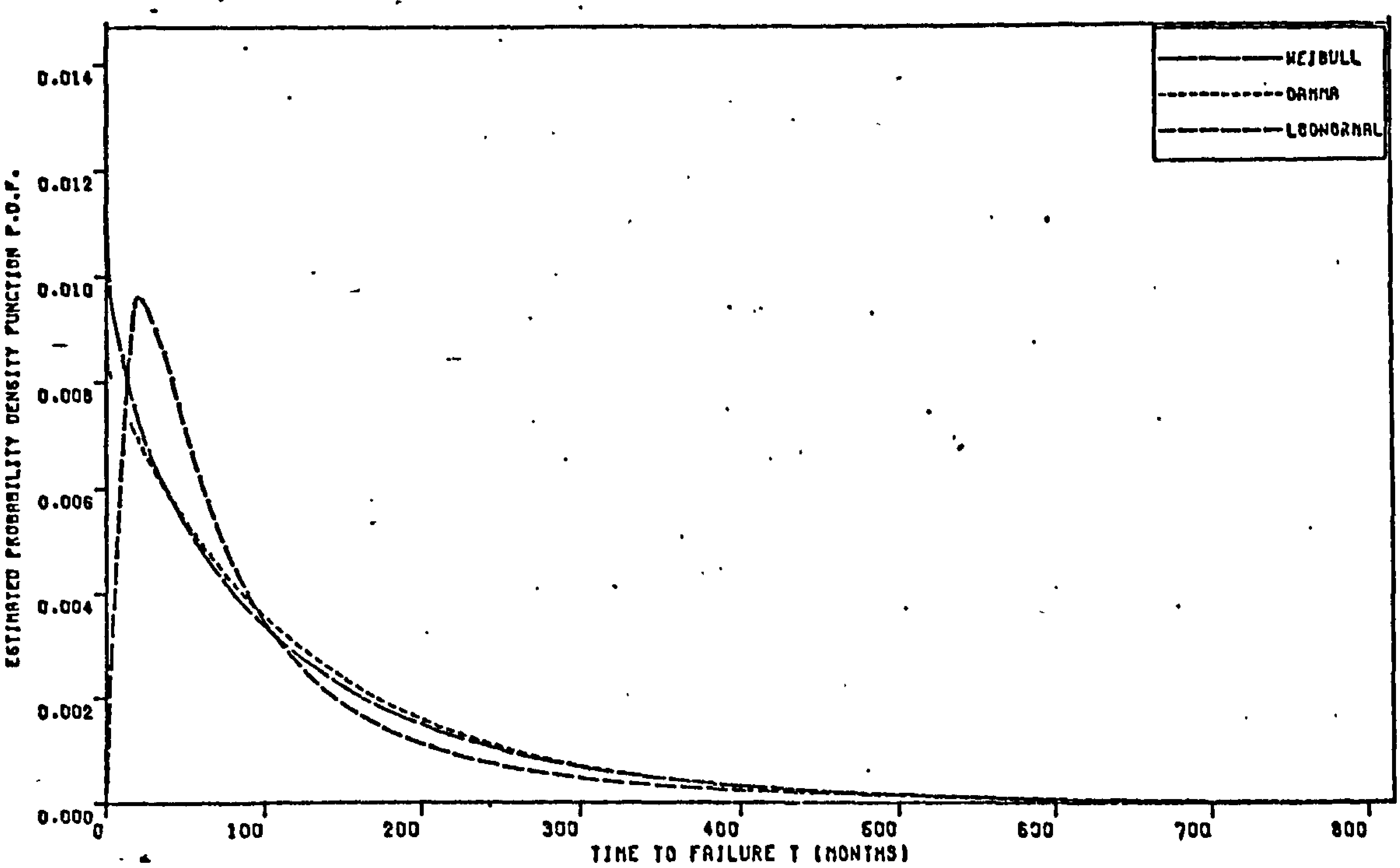


Fig. B.88 FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

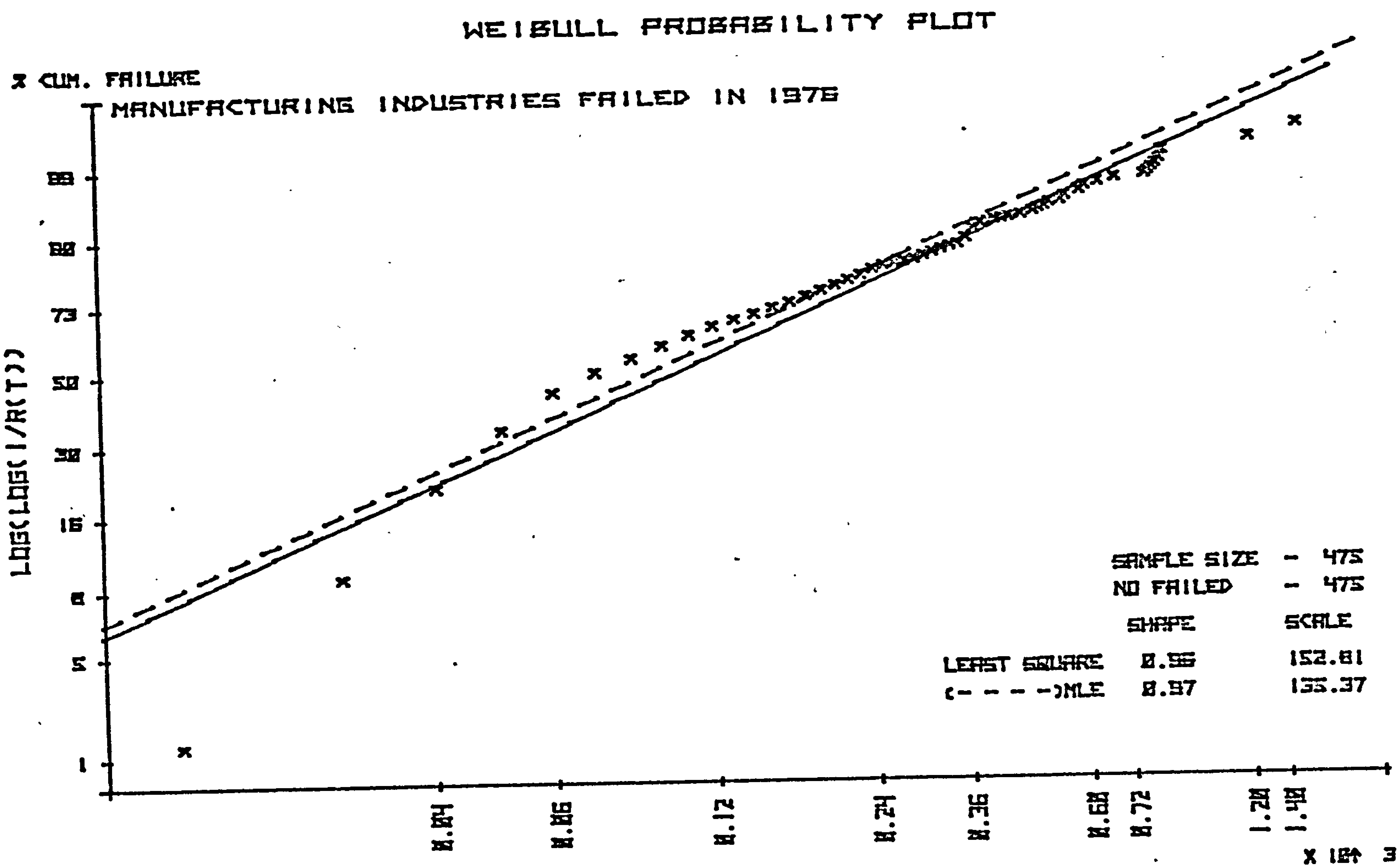

WEIBULL PROBABILITY PLOT
% CUM. FAILURE
MANUFACTURING INDUSTRIES FAILED IN 1978
LOG(LOG(1/R(T)))
SAMPLE SIZE - 475
NO FAILED - 475
SHAPE SCALE
LEAST SQUARE 0.55 152.81
(- - - -)MLE 0.57 155.37
x 10^ 3
LOG(TIME)

Fig. B.89

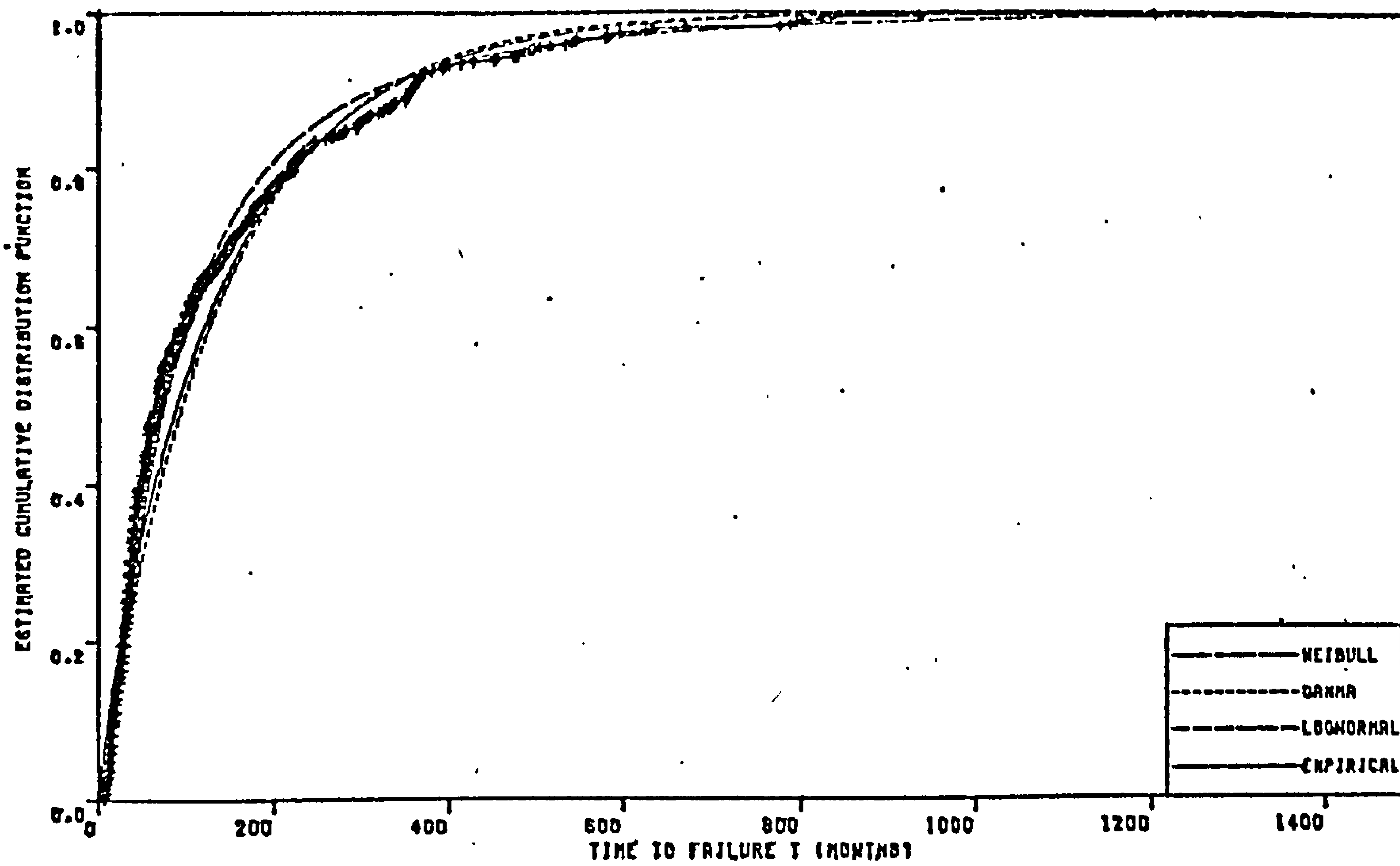


Fig. B.90

FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1976

	SHAPE	SCALE
LOG-NORMAL	1.11	4.33
WEIBULL	0.92	133
GAMMA	0.62	223

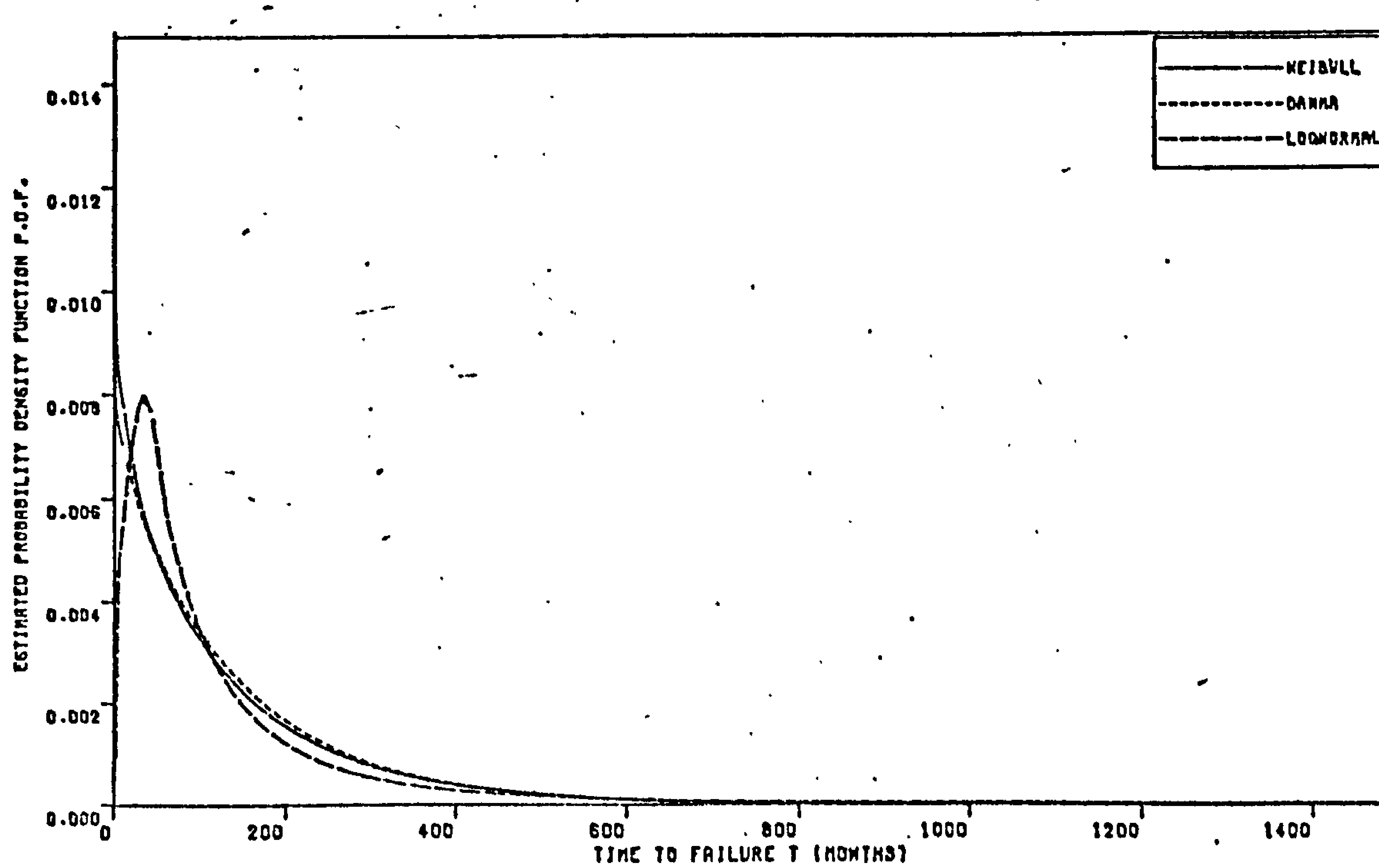


Fig. B.91

FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

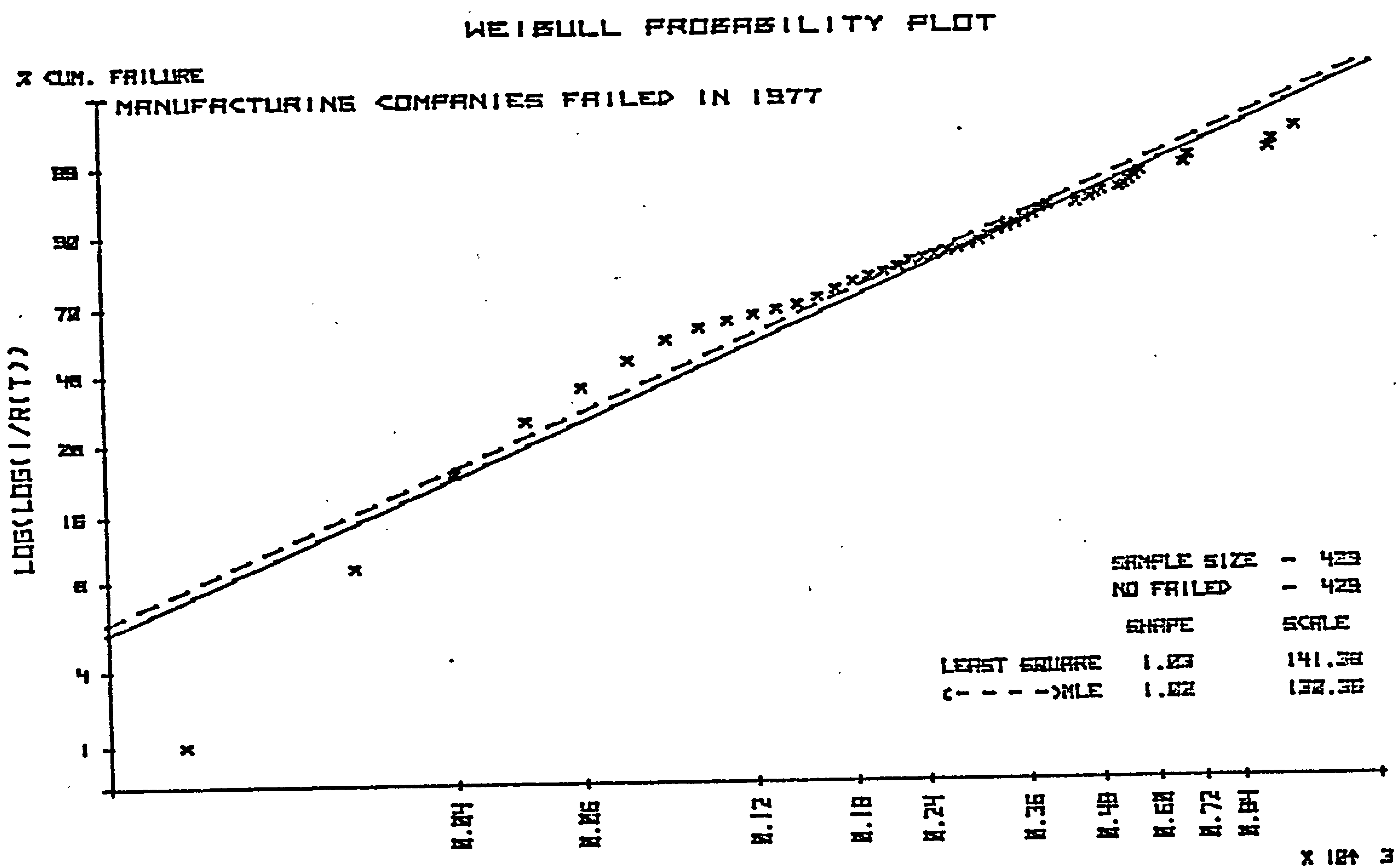

WEIBULL PROBABILITY PLOT
% CUM. FAILURE
MANUFACTURING COMPANIES FAILED IN 1977
LOG(LOG(1/R(T)))
SAMPLE SIZE - 429
NO FAILED - 429
SHAPE
SCALE
LEAST SQUARE 1.03
(- - - -)MLE 1.02
LOG(TIME)

Fig. B.92

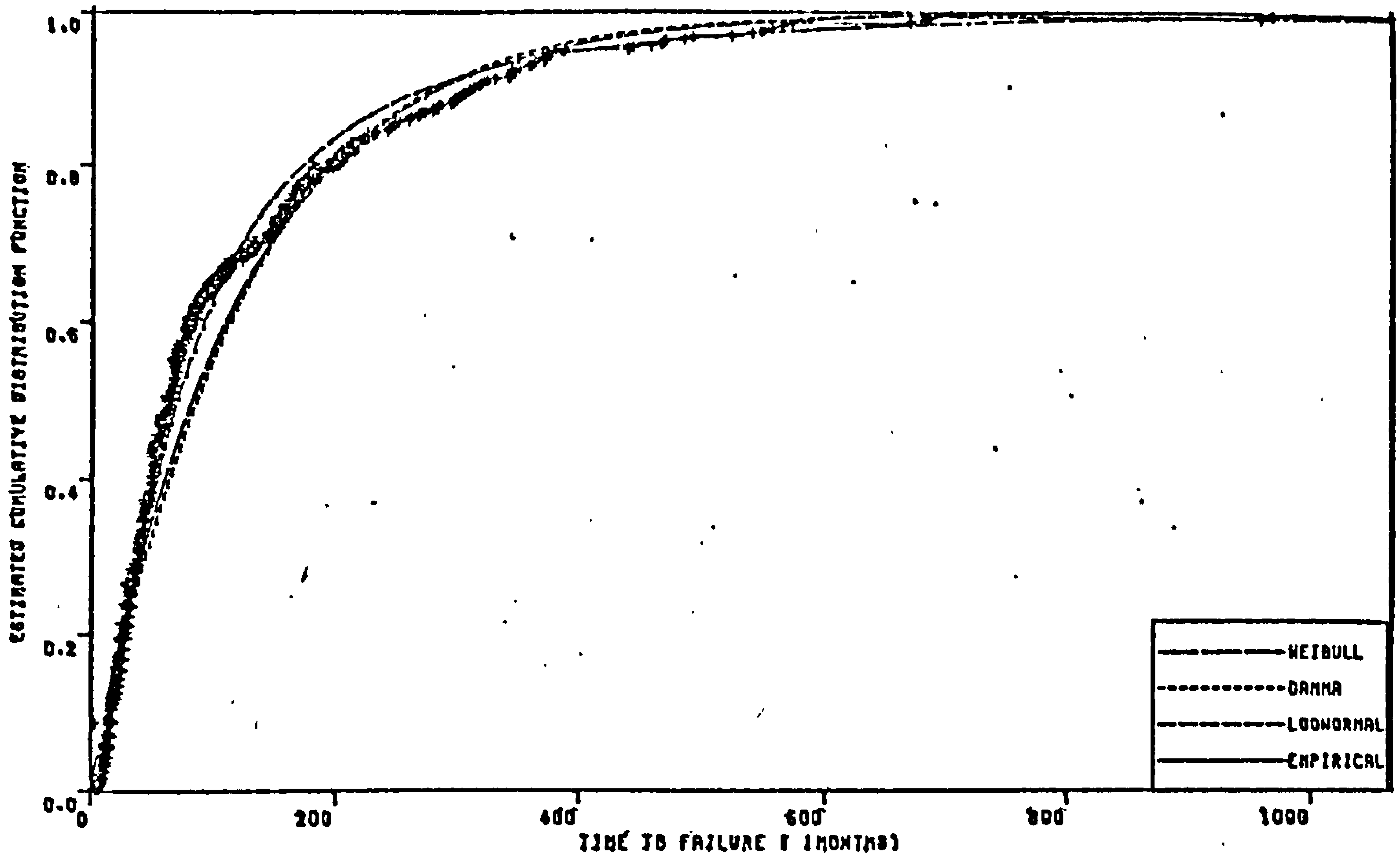


Fig. B.93

FIG : CUMULATIVE DISTRIBUTION FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

MANUFACTURING COMPANIES FAILED IN 1977

	SHAPE	SCALE
LOG-NORMAL	1.06	4.25
WEIBULL	0.96	121
GAMMA	0.69	176

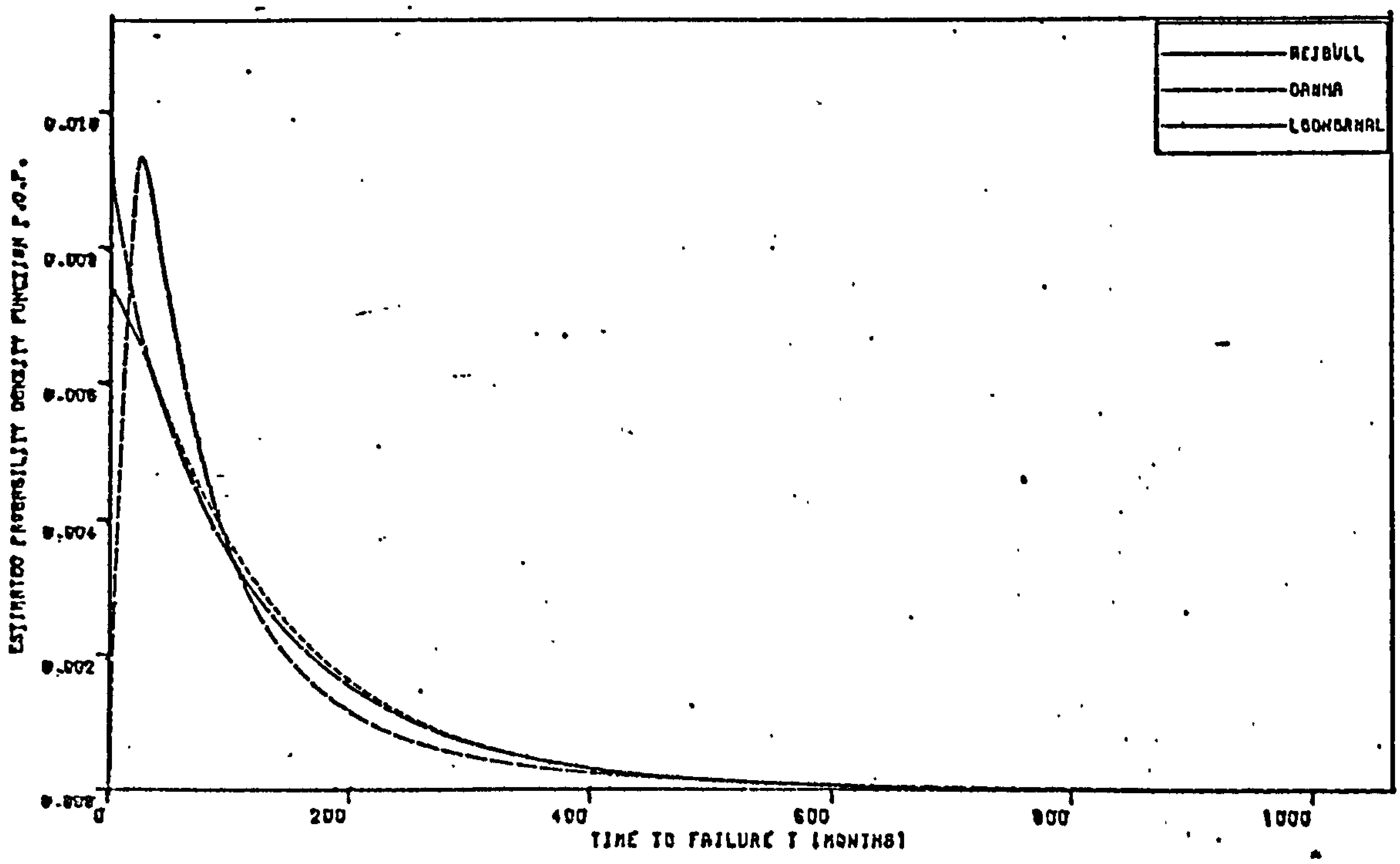


Fig. B.94

FIG : PROBABILITY DENSITY FUNCTIONS
MAXIMUM LIKELIHOOD ESTIMATORS OF PARAMETERS

APPENDIX C

COMPUTER PROGRAMS

The computer programs were originally developed in the Postgraduate School of Industrial Technology, University of Bradford, by A R R Kamath and M. Esfahani. These were modified by the author for the analysis of company failure data. Acknowledgements are due to my colleagues, N ABUSHABAN, A HAMADANI, J MULONDO and A RAISSI who were most helpful in their contribution.

C.1 "BAYS"

1. Function

To fit a five parameter mixed Weibull distribution using the method of weighted maximum likelihood.

2. Programming Language

FORTRAN-IV

3. Subroutines Used

DATAREAD

BUBBLESORT

PROBABILITY

FUNCT

DEVTN

PARA

RESULT

4. Description

This program estimates the parameters of Bimodal Weibull distribution using the weighted likelihood method.

Subroutine DATAREAD reads the input data in a format compatible to the other subroutines. Initial calculations which are common to the rest of the subroutines are also performed in this subroutine.

Subroutine BUBBLESORT rearranges the failure times in an ascending order.

Subroutine PROBABILITY calculates the Bayesian probabilities, given the time of failure and the Weibull parameters for late and early distributions. The proportion of early failures is also calculated as an output.

Subroutine FUNCT calculates the value of the log likelihood function given a set of Bimodal Weibull parameters and the data points.

Subroutine DEVTN calculates the maximum absolute deviation of the sample CDF and the Bimodal Weibull (hypothesised) CDF.

Subroutine PARA calculates new values for the parameters of Bimodal Weibull distributions using the weighted maximum likelihood method.

Subroutine RESULT monitors the iteration.

5. Parameters

NSAMP - An INTEGER quantity describing the total number in the sample.

NFAIL - An INTEGER quantity describing the total number failed

TIME - A one-dimensional REAL ARRAY of at least NSAMP elements containing the values of the failure times (and censored times)

SHAPE1 - A REAL variable representing early failure Weibull shape parameter

SHAPE2 - A REAL variable representing late failure Weibull shape parameter

SCALE1 - A REAL variable representing the early failure Weibull scale parameters

SCALE2 - A REAL variable representing the late failure Weibull scale parameter

TOE1 - A REAL variable representing the reciprocal of the early Weibull scale raised to the power of early shape.

TOE2 - A REAL variable representing the reciprocal of the late Weibull scale raised to the power of late shape

GRADB1 - A REAL variable representing the gradient of the log likelihood function with respect to the current early shape parameter

GRADB2 - A REAL variable representing the gradient of the log likelihood function with respect to the late shape parameter

GRADT1 - A REAL variable representing the gradient of the log likelihood function with respect to the current TOE1

GRADT2 - A REAL variable representing the gradient of the log likelihood function with respect to the current TOE2

VALUE1 - A REAL variable representing the current log likelihood value of early failure Weibull distribution parameters

VALUE2 - A REAL variable representing the current log likelihood value of the current late failure Weibull distribution parameters

DMAX - A REAL variable representing the maximum absolute deviation of the fitted and the hypothesised (Bimodal Weibull) cumulative distribution functions

TME - A REAL variable representing the time at which the maximum absolute deviation DMAX occurs.

PROP1 - A REAL variable representing the current estimate of proportion of early failures

PROP2 - A REAL variable representing the current estimate of proportion of late failures

PROB - A REAL array of DIMENSION at least NSAMP; contains the early failure probabilities of the failure times using the current Bimodal Weibull parameters.

The above variables are declared in COMMON

DATAREAD - SUBROUTINE, reads the input data and assigns values to the variables defined in COMMON

BUBBLESORT - SUBROUTINE, rearranges the first NFAIL elements in the array TIME in an ascending order

PROBABILITY - SUBROUTINE, calculates the Bayesian coefficients of the current set of Bimodal Weibull parameters

PROBABILITY(B1,A1,B2,A2,AJ3,AJ4)

B1 - REAL

On entry, B1 represents early failure Weibull shape parameter

A1 - REAL

On entry, A1 represents early failure Weibull scale parameter

B2 - REAL

On entry, B2 represents late failure Weibull shape parameter

A2 - REAL

On entry, A2 represents late failure Weibull shape parameter

AJ3 - REAL

On exit, AJ3 represents the estimate of proportion of early failures

AJ4 - REAL

On exit, AJ4 represents the estimate of proportion of late failures

FUNCT - SUBROUTINE, calculates the value of the log likelihood function for the current set of Weibull distribution parameters

SUBROUTINE FUNCT(B,TOE,IBETA,VALUE)

B - REAL

On entry, B represents the Weibull shape parameter

TOE - REAL

On entry, TOE represents the reciprocal of the

Weibull scale raised to the power of B

IBETA - INTEGER

On entry, IBETA represents the type of distribution: 1 - if early failure distribution, other if late failure distribution

VALUE - REAL

On exit, VALUE represents the weighted maximum likelihood of the Weibull distribution parameters

DEVTN - SUBROUTINE, calculates the maximum absolute deviation of the theoretical and the sample cumulative distribution functions (CDF).

```
SUBROUTINE DEVTN(B1,A1,B2,A2,T,D,D1)
DIMENSION G(NFAIL), IF(NFAIL), RANK(NFAIL)
```

B1 - REAL

On entry, B1 represents the early failure Weibull shape parameter

A1- REAL

On entry, A1 represents the early failure Weibull scale parameter

B2 - REAL

On entry, B2 represents the late failure Weibull shape parameter

A2 - REAL

On entry, A2 represents the late failure Weibull scale parameter

T -REAL

On entry, T represents the proportion of early failures

D - REAL

On exit, D represents the maximum absolute deviation of the hypothesised and sample CDF

D1 - REAL

On exit, D1 represents the upper limit of the observed time interval at which maximum deviation of the fitted CDF occurs.

G - REAL ARRAY OF DIMENSION (NFAIL)

On exit, the elements of G contain the upper limit of the class intervals of the failure times

IF - INTEGER array of maximum DIMENSION (NFAIL)

On exit, this array would contain the frequency in each class interval.

RANK - INTEGER array of maximum DIMENSION (NFAIL)

On exit, this array would contain the sample cumulative distribution of the data.

PARA - SUBROUTINE, calculates new values for the parameters of Bimodal Weibull distribution using Newton Raphson iterative procedure.

SUBROUTINE PARA(SHAPE,SCALE,IBETA,GRAD1,GRAD2,ITER,TOE)

SHAPE - REAL variable

On entry, representing the shape parameter of Weibull distribution

SCALE - REAL variable

On entry, representing the scale parameter of Weibull distribution.

IBETA - INTEGER variable

On entry, specifying whether an early failure distribution or late failure distribution

1 - for early failure distribution

other - for late failure distribution

GRAD1 - REAL variable

On exit, representing the gradient of the log likelihood function with respect to SHAPE

GRAD2 - REAL variable

On exit, representing the gradient of the log likelihood function with respect to the reciprocal of the SCALE raised to the power of SHAPE

ITER - INTEGER variable

representing a counter to check the number of iterations required for the convergence.

TOE - REAL variable

representing the reciprocal of the SCALE raised to the power of SHAPE

BIMOD - FUNCTION, calculates the cumulative distribution function of Bimodal Weibull distribution, given the parameters

FUNCTION BIMOD(X1,B1,A1,B2,A2,T)

X1 - REAL variable representing the time of failure

B1 - REAL variable representing the early Weibull distribution shape parameter

A1 - REAL variable representing the early Weibull distribution scale parameter

B2 - REAL variable representing the late Weibull distribution shape parameter

A2 - REAL variable representing the late Weibull distribution scale parameter

T - REAL variable representing the proportion of early failures

RESULT - SUBROUTINE, prints out the current values of the output parameters

SUBROUTINE (N)

N - INTEGER

On entry, specifies whether a print out of the Bayesian probabilities is required in every iteration.

6. Input Data

The user must supply the following input data:

1. TITLE - 10A8 FORMAT (reads the title up to 80 characters)
2. NSAMP,NFAIL - 2I0 FORMAT (reads total number in the sample and the number of failure)
3. TIME - 250F0.0 FORMAT (reads the times of failure)
4. CENSOR - F0.0 FORMAT (reads the censored time only if NFAIL<NSAMP)
5. SHAPE1, SCALE1, SHAPE2, SCALE2 - 4F0.0 FORMAT (reads the initial values of early and late failure Weibull distribution parameters)

7. Output

The output includes

1. The number of the current iteration
2. current parameters of the early and late failure Weibull distribution
3. gradients of the maximum likelihood function with respect to the Weibull distribution parameters

4. estimated proportion of early and late failure distributions
5. convergence values (i.e. the absolute difference between the current and the previous sets of parameters)
6. Bayesian probabilities of early and late failure distributions
7. Maximum core used: = 10K words
8. Time required: time required depends on the initial vlaues of the parameter supplied.
9. References: See Chapter 4.

```
      PROGRAM(BAYS)
      INPUT1=CRO
      OUTPUT2=LPO
      TRACE2
      END
      MASTER KAMATH
      COMMON SHAPE1,SHAPE2,SCALE1,SCALE2,TOE1,TOE2,PROP1,PROP2,TIME(250)
     1,PROB(250),NFAIL,NSAMP,GRADB1,GRADB2,GRADT1,GRADT2,VALUE1,VALUE2
     2,DMAX,TME
C        NSAMP- NO IN THE SAMPLE, NFAIL - NO FAILED
C        SHAPE1 EARLY SHAPE, SCALE2 EARLY SCALE
C        THIS PROGRAM CALCULATES THE PARAMETERS OF BIMODAL WEIBULL
C        DISTRIBUTION USING THE WEIGHTED LIKELIHOOD METHOD
      CALL DATAREAD
      CALL BUBBLESORT
      CALL PROBABILITY(SHAPE1,SCALE1,SHAPE2,SCALE2,PROP1,PROP2)
      CALL FUNCT(SHAPE1,TOE1,1,VALUE1)
      CALL FUNCT( SHAPE2,TOE2,2,VALUE2)
      GRADB1=0.0
       GRADB2=0.0
      GRADT1=0.0
      GRADT2=0.0
      CALL DEVTN(SHAPE1,SCALE1,SHAPE2,SCALE2,PROP1,DMAX,TME)
       WRITE(2,100)
  100 FORMAT(1X,'ITERATION 0'//)
       CALL RESULT(1)
      A1=SCALE1
      A2=SCALE2
      B1=SHAPE1
      B2=SHAPE2
      DO  10  I1=1,50
      CALL PARA (SHAPE1,SCALE1,1,GRADB1,GRADT1,ITER,TOE1)
       WRITE(2,200)
  200 FORMAT(' -----------------------------------------------------
     1-----------------------------')
      WRITE(2,300)I1
  300 FORMAT(1X,'ITERATION NO',5X,I5//)
      CALL PARA (SHAPE2,SCALE2,2,GRADB2,GRADT2,ITER,TOE2)
      A3=SCALE1
      B3=SHAPE1
      A4=SCALE2
      B4= SHAPE2
      CONV1=ABS(A1-A3)
      CONV2=ABS(B1-B3)
      CONV3=ABS(A2-A4)
      CONV4=ABS(B2-B4)
       IF(( CONV2.LT.0.00005).AND.(CONV4.LT.0.00005 ))GOTO 20
      GOTO 50
   20 IF ((CONV1.LT.0.0005).AND.(CONV3.LT.0.0005)) GOTO 30
   50 CONTINUE
      A1=A3
      A2=A4
      B1=B3
```

```
      B2=B4
      CALL PROBABILITY(SHAPE1,SCALE1,SHAPE2,SCALE2,PROP1,PROP2)
      CALL FUNCT(SHAPE1,TOE1,1,VALUE1)
      CALL FUNCT(SHAPE2,TOE2,2,VALUE2)
      CALL DEVTN(SHAPE1,SCALE1,SHAPE2,SCALE2,PROP1,DMAX,TME)
      CALL RESULT(1)
       WRITE(2,400)
  400 FORMAT(1X,//' CONVERGENCE VALUES'///)
      WRITE(2,500)
  500 FORMAT(1X,35X,'EARLY',21X,'LATE'///)
       WRITE(2,600)CONV2,CONV4
  600 FORMAT(1X,18X,'SHAPE',8X,F12.6,12X,F12.6/)
      WRITE(2,700)CONV1,CONV2
  700 FORMAT(1X,18X,'SCALE',8X,F12.6,12X,F12.6//)
      WRITE(2,200)
   10 CONTINUE
      WRITE(2,800)
  800 FORMAT(1X,'ITERATIONS EXCEEDED 50'/' FINAL RESULTS ARE:-'//)
   30 CONTINUE
      WRITE(2,900)I1
  900 FORMAT(1X,'AFTER',I5,'ITERATIONS, FINAL VALUES ARE:-'//)
   40 CALL RESULT(1)
      STOP
      END


      SUBROUTINE PROBABILITY(B1,A1,B2,A2,AJ3,AJ4)
C     INDEX OF EXPONENTIAL TESTED IN ORDER TO AVOID UNDER/OVER FLOW
      COMMON SHAPE1,SHAPE2,SCALE1,SCALE2,TOE1,TOE2,PROP1,PROP2,TIME(250)
     1,PROB(250),NFAIL,NSAMP,GRADB1,GRADB2,GRADT1,GRADT2,VALUE1,VALUE2
     2,DMAX,TME

C        THIS SUBROUTINE CALCULATES THE BAYESIAN COEFFICIENTS GIVEN
C        THE EARLY AND THE LATE FAILURE PARAMETERS.
C        AJ3 AND AJ4 ARE THE PROPORTION OF EARLY AND LATE FAILURES
C        RESPECTIVELY.

      AJ3=0.0
      AJ4=0.0
      DO 10 I=1,NSAMP
      X=(TIME(I)/A1)**B1-(TIME(I)/A2)**B2
      IF (I.GE.(NFAIL+1)) GOTO 20
      AJ1=(B2/B1)*(TIME(I)**(B2-B1))*((A1**B1)/(A2**B2))
      IF(ABS((TIME(I)/A1)**B1-(TIME(I)/A2)**B2).LT.100.0) GOTO 30
      IF ((( TIME(I)/A1)**B1-(TIME(I)/A2)**B2).GT. 100.0) GOTO 40
      PROB(I)=1.0
       GOTO 50
   40 CONTINUE
       PROB(I)=0.0
       GOTO 50
   30 CONTINUE
```

```
      AJ1=AJ1*EXP((TIME(I)/A1)**B1-(TIME(I)/A2)**B2)
      PROB(I)=1.0/(1.0+AJ1)
   50 CONTINUE
      AJ3=AJ3+PROB(I)
       AJ4=AJ4+1.0-PROB(I)
      GOTO 10
   20 CONTINUE
      IF(ABS((TIME(I)/A1)**B1-(TIME(I)/A2)**B2).LT. 100.0)  GOTO 60
      IF ((( TIME(I)/A1)** B1-(TIME(I)/A2)**B2).GT.100.0) GOTO 70
       PROB(I)=1.0
      GOTO 10
   70 CONTINUE
      PROB(I)=0.0
       GOTO 10
   60 CONTINUE
       PROB(I)=1.0/(EXP((TIME(I)/A1)**B1-(TIME(I)/A2)**B2)+1.0)
   10 CONTINUE
      AJ3=AJ3/FLOAT(NSAMP)
      AJ4=AJ4/FLOAT(NSAMP)
      RETURN
       END


       SUBROUTINE FUNCT (B,TOE,IBETA,VALUE)
      COMMON SHAPE1,SHAPE2,SCALE1,SCALE2,TOE1,TOE2,PROP1,PROP2,TIME(250)
     1,PROB(250),NFAIL,NSAMP,GRADB1,GRADB2,GRADT1,GRADT2,VALUE1,VALUE2
     2,DMAX,TME

C        THIS SUBROUTINE CALCULATES THE VALUE OF LOG LIKELIHOOD OF
C        WEIBULL DISTRIBUTION GIVEN THE SHAPE(B) AND SCALE(TOE).
C        IBETA IS A COUNTER TO CHECKEARLY OR LATE FAILURES.
C        AND THIS IS USED TO ASSIGN RESPECTIVE BAYESIAN PROBABILITIES
C        AT ANY FAILURE TIME

      P1=0.0
      P2=0.0
      P3=0.0
      DO  10  I= 1, NSAMP
      IF(I.GE.(NFAIL+1)) GOTO 20
      IF(IBETA.EQ.1) GOTO 30
      P1=P1+1.0- PROB(I)
      P2=P2+(1.0-PROB(I))*ALOG(TIME(I))
      P3= P3+(1.0-PROB(I))*TIME(I)**B
      GOTO 20
   30 CONTINUE
      P1=P1+PROB(I)
      P2=P2+PROB(I)*ALOG(TIME(I))
      P3=P3+PROB(I)*TIME(I)**B
   20 CONTINUE
      IF(IBETA.EQ.1) GOTO 40
      P3=P3+(1.0-PROB(I))*TIME(I)**B
```

```
      GOTO 10
   40 P3=P3+PROB(I)*TIME(I)**B
   10 CONTINUE
      VALUE=P1*ALOG(B)+P1*ALOG(TOE)+(B-1.0)*P2-P3*TOE
      RETURN
      END



      SUBROUTINE DEVTN(B1,A1,B2,A2,T,D,D1)
      COMMON SHAPE1,SHAPE2,SCALE1,SCALE2,TOE1,TOE2,PROP1,PROP2,TIME(250)
     1,PROB(250),NFAIL,NSAMP,GRADB1,GRADB2,GRADT1,GRADT2,VALUE1,VALUE2
     2,DMAX,TME
      DIMENSION G(250),IF(250),RANK(250)

C     THIS SUBROUTINE CALCULATES THE MAXIMUM ABSOLUTE DEVIATION
C     OF THE SAMPLE CDF AND THE BIMODAL WEIBULL(HYPOTHSISED) CDF.
C     T IS THE PROPORTION OF EARLY FAILURES.
C     RANK I/N IS USED AN ESTIMATE OF THE SAMPLE CDF.
C     ARRAY G(250) CONTAINS THE UPPER LIMIT OF CLASS INTERVAL.
C     ARRAY IF(250) CONTAINS THE FREQUENCIES AT ANY CLASS INTERVAL.
C     ARRAY RANK(250) CONTAINS THE RANK OF THE SAMPLE DATA( CDF).
C
C     NOTE:- FUNCTION BIMOD IS USED IN CONJUNCTION WITH THIS SUBROUTINE
C            TO CALCULATE THE FITTED (HYPOTHESISED) CDF.
C            ALSO, THE TIMES OF FAILURE T(250) HAS TO BE ARRENGED IN AN
C            ASCENDING ORDER.
C
C     TO FORM THE CLASS INTERVAL AND FREQUENCY.
      I1=1
      IF(I1)=0
      G(I1)=TIME(1)
      DO 10 I=1, NFAIL
   30 IF (TIME(I).NE.G(I1)) GOTO 20
      IF(I1)=IF(I1)+1
      GOTO 10
   20 I1=I1+1
      IF(I1)=0
      G(I1)=TIME(I)
      GOTO 30
   10 CONTINUE
C     TO CALCULATE AND STORE THE MEAN RANK IN THE ARRAY RANK.
      I3=0
      DO 40 I=1,I1
      I3=I3+IF(I)
      IF( IF(I).EQ.1) GOTO 60
      IS=0
      DO 50 J=(I3-IF(I)+1),I3
   50 IS=IS+J
      RANK(I)=FLOAT(IS)/FLOAT(IF(I))/FLOAT(NSAMP)
      GO TO 40
   60 RANK(I)=FLOAT(I3)/FLOAT(NSAMP)
```

```
   40 CONTINUE
C     TO CALCULATE KOLMOGROVE SMIRINOV TEST STATISTIC.
C     DMAX DENOTES THE TEST STATISTC( D)
      T2=G(1)
      T1=0.0
      D=0.0
      DO 70 I=1,I1
      DIST2=BIMOD(G(I),B1,A1,B2,A2,T)
      IF(I.NE.1) GOTO 80
      D1=DIST2
      GOTO 90
   80 D1=ABS(DIST2-RANK(I-1))
   90 D2=ABS(DIST2-RANK(I))
      D3=D1
      IF(D3.GE.D2) GOTO 100
      D3=D2
  100 IF (D3.LE.D) GOTO 70
      D=D3
      IF( I.EQ.1) GOTO 110
      T1=G(I-1)
  110 T2=G(I)
   70 CONTINUE
      D1=T2
      RETURN
      END


      SUBROUTINE  RESULT(N)
C      THIS SUBROUTINE PRINTS OUT RESULTS
      COMMON SHAPE1,SHAPE2,SCALE1,SCALE2,TOE1,TOE2,PROP1,PROP2,TIME(250)
     1,PROB(250),NFAIL,NSAMP,GRADB1,GRADB2,GRADT1,GRADT2,VALUE1,VALUE2
     2,DMAX,TME
       WRITE(2,100)
  100 FORMAT(1X,35X,'EARLY',21X,'LATE',/)
      WRITE(2,200)
  200 FORMAT(1X,28X,'-----------------------------------------------')
       WRITE(2,300)SHAPE1,SHAPE2
  300 FORMAT(1X,18X,'SHAPE',8X,F12.8,12X,F12.8/)
      WRITE(2,400)SCALE1,SCALE2
  400 FORMAT(1X,18X,'SCALE',4X,F20.5,4X,F20.5/)
      WRITE(2,500)TOE1,TOE2
  500 FORMAT(1X,21X,'TOE',4X,F20.15,4X,F20.15/)
      WRITE(2,600)GRADB1,GRADB2
  600 FORMAT(1X,6X,'GRADIENT OF SHAPE',4X,F20.10,4X,F20.10/)
      WRITE(2,700)GRADT1,GRADT2
  700 FORMAT(1X,8X,'GRADIENT OF TOE',4X,F20.10,4X,F20.10/)
      WRITE(2,800)PROP1,PROP2
  800 FORMAT(1X,13X,'PROPORTION',8X,F12.7,12X,F12.7/)
      WRITE(2,1020)VALUE1,VALUE2
 1020 FORMAT(1X,7X,'LIKILIHOOD VALUE',8X,F12.6,12X,F12.6/)
      WRITE(2,200)
      WRITE(2,900)NSAMP,NFAIL
  900 FORMAT(1X,'NO IN SAMPLE=',I5,5X,'NO FAILED',I5/)
```

```
      WRITE(2,1030)DMAX,TME
 1030 FORMAT(1X,'DMAX=',F10.6,5X,'AT TIME',F15.3//)
      IF(N.NE.1)  GOTO  20
      WRITE(2,1000)
 1000 FORMAT(1X,5X,'TIME',10X,'PROBABILITY',/)
      DO  10  I=1,NFAIL
      X=1.0-PROB(I)
      WRITE(2,1010)I,TIME(I),PROB(I),X
 1010 FORMAT(1X,I3,')',F13.2,5X,F12.8,5X,F12.8 )
   10 CONTINUE
   20 CONTINUE
      RETURN
      END


      SUBROUTINE DATAREAD
C       SUBROUTINE TO READ DATA
      COMMON SHAPE1,SHAPE2,SCALE1,SCALE2,TOE1,TOE2,PROP1,PROP2,TIME(250)
     1,PROB(250),NFAIL,NSAMP,GRADB1,GRADB2,GRADT1,GRADT2,VALUE1,VALUE2
     2,DMAX,TME
      DIMENSION  TITLE(10)
      READ(1,100)(TITLE(I),I=1,10)
  100 FORMAT(80A1)
      READ(1,200)NSAMP,NFAIL
  200 FORMAT(2I0)
      READ(1,300)(TIME(I),I=1,NFAIL)
  300 FORMAT(250F0.0)
      IF (NFAIL.EQ.NSAMP)  GOTO 10
      READ(1,400)CENSOR
  400 FORMAT(F0.0)
      DO  20  I=(NFAIL+1)  ,   NSAMP
      TIME(I)=CENSOR
   20 CONTINUE
   10 CONTINUE
      READ(1,500)SHAPE1,SCALE1,SHAPE2,SCALE2
  500 FORMAT(4F0.0)
      TOE1=1.0/(SCALE1**SHAPE1)
      TOE2=1.0/(SCALE2**SHAPE2)
      WRITE(2,600)(TITLE(I),I=1,10)
  600 FORMAT(1X,//,80A1,//)
      WRITE(2,700)NSAMP,NFAIL
  700 FORMAT(1X,'NO IN THE SAMPLE=',I5,5X,'NO FAILED=',I5//' FAILURE TIM
     1ES')
      WRITE(2,800)(TIME(I),I=1,NFAIL)
  800 FORMAT(1X,200(F15.2/)//)
      WRITE(2,900)SHAPE1,SCALE1,SHAPE2,SCALE2
  900 FORMAT(1X,'EARLY SHAPE-',F10.6,5X,'EARLY SCALE-',F15.3//' LATE SHA
     UPE-',F10.6,5X,'LATE SCALE-',F15.3///)
      RETURN
      END


      SUBROUTINE BUBBLESORT
C     THIS SUBROUTINE REARRENGES THE ARRAY IN AN ASCENDING ORDER
```

```
      COMMON SHAPE1,SHAPE2,SCALE1,SCALE2,TOE1,TOE2,PROP1,PROP2,TIME(250)
     1,PROB(250),NFAIL,NSAMP,GRADB1,GRADB2,GRADT1,GRADT2,VALUE1,VALUE2
     2,DMAX,TME
      DO  10 J=1,(NFAIL-1)
      J1=NFAIL-J
      DO  20  I=  1,J1
      I6=I+1
      IF( TIME(I6).GT. TIME(I))  GOTO 20
       X6=TIME(I6)
      TIME(I6)=TIME(I)
      TIME(I)=X6
   20 CONTINUE
   10 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE PARA(SHAPE,SCALE,IBETA,GRAD1,GRAD2,ITER,TOE)
      COMMON SHAPE1,SHAPE2,SCALE1,SCALE2,TOE1,TOE2,PROP1,PROP2,TIME(250)
     1,PROB(250),NFAIL,NSAMP,GRADB1,GRADB2,GRADT1,GRADT2,VALUE1,VALUE2
     2,DMAX,TME
C        THIS SUBROUTINE CALCULATES NEW VALUES FOR THE PARAMETERS
C        OF BIMODAL WEIBULL USING WEIGHTED MLE: NEWTON-RAPHSONS METHOD
C        IS USED FOR THE ITERATION.
C        IBETA IS A COUNTER TO CHECK LATE EARLY FAILURES.
           M=0
      B=SHAPE
      AK3=0.0
       P1=0.0
      DO 10 I=1,NFAIL
       IF(IBETA.EQ.1)  GOTO  20
      P1=P1+(1.0-PROB(I))*ALOG(TIME(I))
      AK3=AK3+(1.0-PROB(I))
      GOTO 10
   20 CONTINUE
      P1=P1+PROB(I)*ALOG(TIME(I))
      AK3=AK3+PROB(I)
   10 CONTINUE
       DO 30 J=1,100
   90 P2=0.0
      P3=0.0
      P4=0.0
      DO 40 I= 1,NSAMP
      IF(IBETA.EQ.1)  GOTO 50
      P2=P2+(1.0-PROB(I))*(TIME(I)**B)*ALOG(TIME(I))
      P3=P3+(1.0-PROB(I))*(TIME(I)**B)
      P4=P4+(1.0-PROB(I))*(TIME(I)**B)*(ALOG(TIME(I)))**2
      GOTO  40
   50 CONTINUE
      P2=P2+PROB(I)*(TIME(I)**B)*ALOG(TIME(I))
      P3=P3+PROB(I)*(TIME(I)**B)
```

```
      P4=P4+PROB(I)*(TIME(I)**B)*(ALOG(TIME(I)))**2
   40 CONTINUE
      IF(M.EQ.1)  GOTO 100
      B7=AK3/B+P1-(AK3/P3)
      B7=AK3/P3*P2
       B8=(AK3/B)+P1-B7
      B7=(P4,P3)-(P2/P3)*(P2/P3)
      B9=-AK3/(B*B)-AK3*B7
      B7=B-(B8/B9)
      IF(ABS(B8).LT.0.00005) GOTO 60
      B=B7
   30 CONTINUE
   60 B=B7
      SHAPE=B
       M=1
       GOTO 90
  100 CONTINUE
      TOE=AK3/P3
        SCALE=(P3/AK3)**(1.0/B)
      ITER=J
      GRAD1=(AK3/B)+P1-(AK3/P3)*P2
      GRAD2=(AK3/TOE)-P3
C     END OF THE SUBROUTINE
      RETURN
      END


      FUNCTION BIMOD(X1,B1,A1,B2,A2,T)
C     THIS FUNCTION CALCULATES BIMODAL WEIBULL CDF AT TIME X1
C     GIVEN THE PARAMETERS B1,A1,B2,A2,T.
C      T BEING PROPORTION OF EARLY FAILURES.
C      TO CHECK INDEX OF THE EXPONENTIAL.
      IF(((X1/A1)**B1).LT.(100.0)) GOTO 10
      X2=1.0
      GOTO 20
   10 X2=1.0-EXP(-((X1/A1)**B1))
   20 IF (((X1/A2)**B2).LT.(100.0)) GOTO 30
      X3=1.0
      GOTO 40
   30 X3=1.0-EXP(-((X1/A2)**B2))
   40 BIMOD=T*X2+(1.0-T)*X3
      RETURN
      END
      FINISH
****
```

C.2 Distributions

1. Description:

The programme gives the best distribution function for a given set of data, based on the maximum likelihood estimation and the Kolmorogov-Smirnov test. The statistical distribution functions used in this program are:

Weibull

Normal

Gamma

Exponential

Lognormal

Erlang

The program uses the Newton-Raphson method to solve the nonlinear equation. This program also tests the given data for randomness.

2. Programming Language

FORTRAN

3. References

The methods used in this program are described in the following references

4. Subroutine used

WEILEST, WEILTEST, NORMAL, GAMMA, LOGNORM, EXPON, ERLANG, ORD, RUNTEST

5. Input Data

The user must supply the following input cards:

NF, INT, MOPT, BEGIN, FORMAT (314, 2F8.2)

W FORMAT (10 F0.0)

6. Parameters

W - A one dimensional REAL ARRAY containing the failure observation data.

NF - An INTEGER quantity describing the number of failure data points

CX - A one dimensional REAL ARRAY containing the values of the cumulative distribution function

FE - A one dimensional REAL ARRAY containing the values of histograms

MOPT - An INTEGER QUANTITY, if it is equal to zeʋo, the data are not ordered,otherwise it is.

BEGIN - A REAL quantity containing the first failure observation

END - A REAL quantity containing the last value of failure data

F - A one dimensional REAL ARRAY containing the values of observed frequency function

7. Output

The output includes, for each distribution function the listing of all the input, the theoretical and empirical distribution and the best estimators of the parameters and also the best distribution function is printed.

```
       PROGRAM (DISTRIBUTIONS)
       INPUT 1 = CRO
       OUTPUT 2 = LPO
       TRACE 2
       END
       MAsTER (moJAHED)
       DIMENSION W(999),CX(999),FE(999),TITLE(10)
       READ(1,22) (TITLE(I),I=1,10)
   22  FORMAT (10A8)
       WRITE(2,23)(TITLE(I),I=1,10)
   23  FORMAT (///1X,10A8,///)
  1    READ(1,20)NF,MOPT,BEGIN,END
       NT=NF
   20  FORMAT(2I0,2F0.0)
       IF(NT-999)2,3,3
  2    READ(1,19)(W(I),I=1,NT)
   19  FORMAT (999F0.0)
       IF(MOPT)5,5,6
  5    CALL RUNTEST(W,NF)
       CALL ORD(W,NF)
  6    WRITE(2,200)(W(I),I=1,NT)
  200  FORMAT(10(2X,F8.3))
       INT=12
       CALL WEILEST(W,NT,NF,BETA,ALFA,XLANDA)
       CALL WEILTEST(W,NT,NF,BETA,ALFA)
       CALL NORMAL(W,NF)
       CALL EXPON(W,NF)
       CALL LOGNORM(W,NF)
       CALL GAMMA (W,NT)
       WRITE(2,4)
 4     FORMAT(////)
       GO TO 1
 3     STOP
       END
       SUBROUTINE RUNTEST(X,NF)
       DIMENSION R(999),X(999)
       AA=NF
       AB=NT
       WRITE(2,300)
       WRITE(2,100)
 100   FORMAT(12X,'RUN TEST')
       WRITE(2,200)
 200   FORMAT(' RUNS ABOVE AND BELOW THE MEADIAN')
       XR=1.
       DO 1 I=1,NF
 1     R(I)=X(I)
       CALL ORD(R,NF)
       J=NF/2
       IF(NF-2*J)2,3,2
 2     XMED=R(J+1)
```

```
      GO TO 4
3     XMED=(R(J)+R(J+1))/2
4     DO 7 I=1,NF
      IF(X(I)-XMED)5,5,6
5     R(I)=1
      GO TO 7
6     R(I)=2
7     CONTINUE
      DO 9 I=2,NF
      IF(R(I)-R(I-1))8,9,8
8     XR=XR+1
9     CONTINUE
      EXR=(AA+2)/2.0
      VARR=(AA*(AA-2))/(4*(AA-1))
      Z=(XR-EXR)/(VARR**0.5)
      Y=ABS(Z)
      IF(Y-2.58)10,10,12
10    WRITE(2,11)
11    FORMAT(' AT.01 SIGNIFICANCE LEVEL SAMPLE IS A RANDOM SAMPLE')
      GO TO 14
12    WRITE(2,13)
13    FORMAT(' AT.01 SIGNIFICANCE LEVEL DATA IS NOT A RANDOM SAMPLE')
300   FORMAT(////)
14    RETURN
      END
      SUBROUTINE ORD(W,NT)
      DIMENSION W(999)
      DO 2 J=1,NT-1
      L=J+1
      DO 2 I=L,NT
      IF(W(J)-W(I))2,2,3
3     W1=W(J)
      W(J)=W(I)
      W(I)=W1
2     CONTINUE
      RETURN
      END
      SUBROUTINE HIST(X,K,INT,MOPT,BEGIN,END,CX,FE)
      DIMENSION CX(999),FE(12),X(999)
      WRITE(2,300)
300   FORMAT(/////)
      DATA NSTAR/'*'/
      IF(MOPT)1,1,2
1     A=X(1)
      Z=X(K)
      J=1
      GO TO 8
2     A=BEGIN
      Z=END
      DO 4 J=1,K
      IF(X(J)-A)4,7,7
4     CONTINUE
```

```
5      WRITE(2,6)
6      FORMAT(50H OTHERE ARE NO OBSERVATIONS IN THE SPECIFIED RANGE)
       RETURN
7      IF(X(J)-Z)8,8,5
8      WRITE(2,9)
9      FORMAT(/37H      NO.    P(X)     F(X)      HISTOGRAM/)
       AK=K
       CUM=0.
       CU=0.
       AINT=INT
       WIDTH=(Z-A)/AINT
       CENTER=A+WIDTH/2
       REP=A+WIDTH
       DO 18 I=1,INT
       NOB=-1
       J=J-1
10     NOB=NOB+1
       J=J+1
       IF(K-J+1)12,12,11
11     IF(REP+.00005-X(J))12,10,10
12     C=CENTER+.00001
       IF(NOB)15,15,13
13     ANOB=NOB
       PROB=ANOB/AK
       CUM=CUM+PROB
       P=PROB+.00005
       CU=CUM+.00005
       WRITE(2,14)NOB,P,CU,C,(NSTAR,IK=1,NOB)
14     FORMAT(I7,F9.4,F8.4,F10.4,2X,75A1)
       GO TO 17
15      WRITE(2,16)CU,C
16     FORMAT(16H      0      .0000,F8.4,F10.4)
17     CENTER=CENTER+WIDTH
       REP=REP+WIDTH
       FE(I)=P
       CX(I)=C
18     CONTINUE
       RETURN
       END
       SUBROUTINE WEILEST(W,NT,NF,BETA,ALFA,XLANDA)
       DIMENSION W(999)
       AB=NT
       AA=NF
       WRITE(2,300)
300    FORMAT(/////)
       XZ=W(1)
       DO 20 I=1,NT
20     W(I)=W(I)/XZ
       EPS=1.0E-6
       BETA=1.0
1      S1=0
       S2=0
```

```
      S3=0
      S4=0
      DO 2 I=1,NT
      S1=S1+W(I)**BETA
      S2=S2+(W(I)**BETA)*ALOG(W(I))
2     S3=S3+(W(I)**BETA)*((ALOG(W(I)))**2)
      DO 3 I=1,NF
3     S4=S4+ALOG(W(I))
      FB=(-AA/S1)*S2+AA/BETA+S4
      FDIFB=AA*(S2**2)/(S1**2)-(AA/S1)*S3-AA/(BETA**2)
      IF(ABS(FB/FDIFB)-EPS)200,200,100
100   BETA=BETA-FB/FDIFB
      GO TO 1
200   WRITE(2,10)BETA
10    FORMAT(2X,'SHAPE PARAMETER BETA=',F5.3)
      AM=-1.0/BETA
      S=S1*(XZ**BETA)
      ALFA=(AA/S)**AM
      WRITE(2,11)ALFA
11    FORMAT(2X,'SCALE PARAMETER ALFA=',F5.3)
      XLANDA=AA/S
      DO 4 I=1,NT
4     W(I)=W(I)*XZ
      RETURN
      END
      SUBROUTINE WEILTEST(W,NT,NF,BETA,ALFA)
      DIMENSION W(999)
      DIMENSION FEM(999),F(999),D(999),N(999),Z(999)
      WRITE(2,300)
      SD=0.
      SUM=0.
      ST=0.
      WRITE(2,90)
90    FORMAT(8X,'GOODNESS OF FIT TEST')
      WRITE(2,91)
91    FORMAT(8X,'BY KOLMOGROV-SMIRNOV TEST')
      WRITE(2,93)
      WRITE(2,300)
93    FORMAT(8X,'FOR WEIBULL DIST.')
      WRITE(2,300)
      WRITE(2,100)
100   FORMAT('     N(I)      FEM(I)      F(I)      D(I)')
      DO 63 I=1,NF
      N(I)=I
      XK=I
      FEM(I)=XK/(NT+1)
      F(I)=1-EXP(-(W(I)/ALFA)**BETA)
63    D(I)=ABS(FEM(I)-F(I))
      WRITE(2,99)(N(I),FEM(I),F(I),D(I),I=1,NT)
99    FORMAT(2X,I3,4X,3F10.4)
      DMAX=XMAX(D,NT)
      WRITE(2,101)DMAX,NT
```

```
101     FORMAT(2X,'DMAX=',F5.3,4X,'NO.=',I3)
C       CRITICAL STATISTIC FOR K-S TEST IS 1.36/KM*1/2 AT 0.05
        IF(NT-40)70,70,21
21      IF(DMAX-1.36/(NT**0.5))633,633,635
633     WRITE(2,634)
634     FORMAT(2X,'AT ALFA=.05 THE DATA ARE DIST. AS A WEIBULL')
        GO TO 70
635     WRITE(2,636)
636     FORMAT(2X,'AT ALFA=.05 THE DATA ARE NOT DIST. AS A WIBULL')
20      WRITE(2,300)
300     FORMAT(/////)
  70    RETURN
        END
        SUBROUTINE NORMAL(X,NT)
        DIMENSION Z(999),FEM(999),F(999),D(999),N(999),X(999)
        WRITE(2,300)
        WRITE(2,71)
71      FORMAT(8X,'FOR NORMAL DIST.')
        WRITE(2,200)
200     FORMAT('      N(I)      FEM(I)      F(I)      D(I)')
        Z1=XMEAN(X,NT)
        Z2=SD(X,NT)
        DO 88 I=1,NT
88      Z(I)=(X(I)-Z1)/Z2
        FS=0
        XJ=-4.0
        S1=0.39895*(EXP(-0.5*(XJ**2)))
        DO 1 I=1,NT
2       XJ=XJ+0.01
        S2=0.39895*(EXP(-0.5*(XJ**2)))
        FS=FS+((S2+S1)/2)*0.01
        S1=S2
        IF(XJ-Z(I))2,3,3
3       F(I)=FS
        XY=I
        FEM(I)=XY/(NT+1)
        N(I)=I
1       D(I)=ABS(FEM(I)-F(I))
        WRITE(2,99)(N(I),FEM(I),F(I),D(I),I=1,NT)
99      FORMAT(2X,I3,4X,3F10.4)
        DMAX=XMAX(D,NT)
        WRITE(2,15)DMAX,NT
15      FORMAT(2X,'DMAX=',F6.3,4X,'NO.=',I4)
        WRITE(2,300)
        WRITE(2,31)Z1
        WRITE(2,32)Z2
31      FORMAT(2X,'MEAN=',F6.3)
32      FORMAT(2X,'SD=',F6.3)
300     FORMAT(///)
        RETURN
        END
        SUBROUTINE GAMMA(X,NT)
```

```
      DIMENSION FEM(999),F(999),D(999),N(999),X(999)
      WRITE(2,300)
      WRITE(2,100)
100   FORMAT(8X,'FOR GAMMA DIST.')
      Z=X(1)
      DO 1 I=1,NT
1     X(I)=X(I)/Z
      Z1=XMEAN(X,NT)
      Z2=SD(X,NT)
      B=(Z2**2)/Z1
      C=(Z1/Z2)**2
      GAM=S14AAF(C,0)
      XJ=0.01
      S1= ((XJ/B)**(C-1))*(EXP(-XJ/B))/(B*GAM)
      FS=((S1/2)*0.01)
      DO 5 I=1,NT
3     XJ=XJ+0.01
      S2=((XJ/B)**(C-1))*(EXP(-XJ/B))/(B*GAM)
      FS=FS+((S1+S2)/2)*0.01
      S1=S2
      IF(XJ-X(I))3,4,4
4     F(I)=FS
      N(I)=I
      XI=I
      FEM(I)=XI/(NT+1)
5     D(I)=ABS(F(I)-FEM(I))
      DMAX=XMAX(D,NT)
      WRITE(2,200)
200   FORMAT('     N(I)       FEM(I)       F(I)       D(I)')
      WRITE(2,99)(N(I),FEM(I),F(I),D(I),I=1,NT)
99    FORMAT(2X,I3,4X,3F10.4)
      WRITE(2,15)DMAX,NT
15    FORMAT(2X,'DMAX=',F6.3,4X,'NO.=',I3)
      B=B*Z
      WRITE(2,101)C
101   FORMAT(2X,'SHAPE PARAMETER=',F8.3)
      WRITE(2,102)B
102   FORMAT(2X,'SCALE PARAMETER=',F8.3)
300   FORMAT(///)
      DO 2 I=1,NT
2     X(I)=X(I)*Z
      RETURN
      END
      SUBROUTINE ERLANG(NT,X)
      DIMENSION X(999),FEM(999),F(999),D(999),N(999)
      REAL K,IX
      WRITE(2,300)
      WRITE(2,200)
200   FORMAT(8X,'ERLANG DISTRIBUTION')
      WRITE(2,100)
100   FORMAT('     N(I)       FEM(I)       F(I)       D(I)')
      ST=0
```

```
      SUM=0.
      Z=X(1)
      DO 5 I=1,NT
5     X(I)=X(I)/Z
      Z1=XMEAN(X,NT)
      Z2=SD(X,NT)
      C=(Z1/Z2)**2
      B=(Z2**2)/Z1
      IC=C+0.5
      IM=IC-1
      DO 2 I=1,NT
      SUM=1+X(I)/B
      DO 1 J=2,IM
      K=J
      IX=J
 3    IX=IX-1
      K=K*IX
      IF(IX-1)1,1,3
1     SUM=SUM+((X(I)/B)**J)/K
      F(I)=1-(EXP(-X(I)/B))*SUM
      ZI=I
      FEM(I)=ZI/(NT+1)
      N(I)=I
 2    D(I)=ABS(F(I)-FEM(I))
      WRITE(2,99)(N(I),FEM(I),F(I),D(I),I=1,NT)
99    FORMAT(2X,I3,4X,3F10.4)
      DMAX=XMAX(D,NT)
      WRITE(2,101)DMAX,NT
101   FORMAT(2X,'DMAX=',F6.3,4X,'NO.=',I3)
      WRITE(2,300)
      C=C*(Z**2)
      B=B/Z
      IC=C+0.5
      WRITE(2,10)IC
10    FORMAT(2X,'SHAPE PARAMETER=',I8)
      WRITE(2,11)B
11    FORMAT(2X,'SCALE PARAMETER =',F6.3)
300   FORMAT(///)
      DO 4 I=1,NT
4     X(I)=X(I)*Z
      RETURN
      END
      SUBROUTINE EXPON(X,NT)
      DIMENSION FEM(999),F(999),D(999),N(999),X(999)
      WRITE(2,300)
      WRITE(2,200)
200   FORMAT(8X,'EXPONANTIAL DISTRIBUTION')
      WRITE(2,100)
100   FORMAT('     NO.      FEM(I)      F(I)      D(I)')
      B=XMEAN(X,NT)
      DO 2 I=1,NT
      N(I)=I
      F(I)=1-EXP(-X(I)/B)
      Z=I
```

```
      FEM(I)=Z/(NT+1)
2     D(I)=ABS(FEM(I)-F(I))
      WRITE(2,3)(N(I),FEM(I),F(I),D(I),I=1,NT)
3     FORMAT(2X,I3,4X,3F10.4)
      DMAX=XMAX(D,NT)
      WRITE(2,4)DMAX,NT
4     FORMAT(2X,'DMAX=',F6.4,4X,'NO=.',I3)
      WRITE(2,5)B
5     FORMAT(2X,'SCALE PARAMETER=',F8.4)
300   FORMAT(////)
      RETURN
      END
      SUBROUTINE LOGNORM(X,NT)
      DIMENSION FEM(999),F(999),N(999),D(999),X(999)
      WRITE(2,300)
      WRITE(2,200)
200   FORMAT(8X,'LOGNORMAL DISTRIBUTION')
      WRITE(2,100)
100   FORMAT('     NO.     FEM(I)     F(I)     D(I)')
      SUM=0.
      ST=0.
      ZN=X(1)
      DO 1 I=1,NT
1     X(I)=X(I)/ZN
      DO 2 I=1,NT
2     SUM=SUM+ALOG(X(I))
      XMEAN=SUM/NT
      XM=EXP(XMEAN)
      DO 3 I=1,NT
 3    ST=ST+(ALOG(X(I))-XMEAN)**2
      SD=(ST/(NT-1))**0.5
      XI=0.01
      XA=(-(ALOG(XI/XM))**2)/(2*(SD**2))
      S1=(0.39885/(XI*SD))*EXP(XA)
      FS=(S1/2)*0.01
      DO 8 I=1,NT
6     XI=XI+0.01
      XA=(-(ALOG(XI/XM))**2)/(2*(SD**2))
      S2=(0.39885/(XI*SD))*EXP(XA)
      FS=FS+((S2+S1)/2)*0.01
      S1=S2
      IF(XI-X(I))6,7,7
7     F(I)=FS
      Z1=I
      FEM(I)=Z1/(NT+1)
      N(I)=I
8     D(I)=ABS(FEM(I)-F(I))
      WRITE(2,9)(N(I),FEM(I),F(I),D(I),I=1,NT)
9     FORMAT(2X,I3,4X,3F10.4)
      DMAX=XMAX(D,NT)
      WRITE(2,10)DMAX,NT
10    FORMAT(2X,'DMAX=',F6.3,4X,'N=',I3)
```

```
      WRITE(2,300)
      XMEAN=XMEAN+ALOG(ZN)
      XM=EXP(XMEAN)
      WRITE(2,11)XM,SD
11    FORMAT(2X,'SCALE PARAMETER=',F6.3,4X,'SHAPE PARAMETER=',F6.3)
300   FORMAT(///)
      DO 4 I=1,NT
4     X(I)=X(I)*ZN
      RETURN
      END
      FUNCTION XMEAN(X,NT)
      DIMENSION X(999)
      SUM=0
      DO 1 I=1,NT
1     SUM=SUM+X(I)
      XMEAN=SUM/NT
      RETURN
      END
      FUNCTION SD(X,NT)
      DIMENSION X(999)
      Z1=XMEAN(X,NT)
      ST=0.
      DO 1 I=1,NT
1     ST=ST+(X(I)-Z1)**2
      SD=(ST/(NT-1))**0.5
      RETURN
      END
      FUNCTION XMAX(D,NT)
      DIMENSION D(999)
      XMAX = D(1)
      DO 1 I = 2,NT

      IF (XMX-D(I))2,1,1
2     SUB=XMAX
      XMAX=D(I)
      D(I)=SUB
1     CONTINUE
      RETURN
      END
      FINISH
****
```

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